

For Reference

NOT TO BE TAKEN FROM THIS ROOM

Ex LIBRIS
UNIVERSITATIS
ALBERTAENSIS





Digitized by the Internet Archive
in 2022 with funding from
University of Alberta Library

<https://archive.org/details/Sutherland1971>

THE UNIVERSITY OF ALBERTA

THE MICROFAUNA OF THE LOWER NEOGASTROPLITES ZONE,
NORTHEASTERN BRITISH COLUMBIA

by



GEORGE DONALD SUTHERLAND

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF GEOLOGY

EDMONTON, ALBERTA

SPRING, 1971

ABSTRACT

Thirty-seven species belonging to sixteen genera of arenaceous foraminifers and one species of radiolarian (Dictyomitra) are figured and described from the mid-Cretaceous lower Neogastrolites zone of the Fort St. John Group of the Moberly Lake area of northeastern British Columbia, Canada. The benthonic foraminiferal assemblage contains Bathysiphon (1 species), Saccamina (5), Ammodiscus (2), Glomospira (1), Trochamminoides (1), Reophax (2), Miliammina (4), Psamminopelta (1), Haplophragmoides (5), Ammobaculites (3), Textularia (3), Trochammina (4), Verneuilina (1), Verneuulinoides (2), "Tritaxia" (1) and Gaudryina (1).

Correlative elements indicate a relationship with the boreal faunas of the Grandstand and Topagoruk Formations of the Alaskan coast and with forms from the Graneros and Mowry Formations of the western interior United States. The accompanying ammonite, Neogastrolites haasi, indicates a late Albian age for the sampled strata. Local forms such as Haplophragmoides postis have been retained from middle Albian and other forms such as Ammobaculites pacalis continued on to earliest Turonian suggesting a continuity of the endemic fauna from Lower Cretaceous to Upper Cretaceous. The fauna has been recognized in part from the Sikanni sands of the type area on the Sikanni Chief River of northeastern British Columbia and from the type Shaftesbury Formation near Judah, Alberta.

The sediments were deposited in the shallow, slightly freshened margins of the euxinic Mowry sea near the base of the upper, aerated layer, near the northeastern pinchout margin of the Goodrich Sandstone Formation.

ACKNOWLEDGEMENTS

Sincerest thanks are expressed to Dr. C.R. Stelck for his guidance and encouragement. The writer expresses thanks to Mr. T. Patterson for assisting in collecting additional samples to supplement those collected by Dr. C.R. Stelck and Dr. G.D. Williams. The writer is indebted to Dr. J.H. Wall of the Research Council of Alberta who assisted in locating foraminiferal types, made available his personal knowledge and pertinent literature on the subject and gave helpful criticisms of the systematic descriptions.

The new technique of photographing was developed in cooperation with Dr. R. Harland. Mr. F. Dimitrov photographed and printed the fossil plates. Mr. V. Kalutich assisted in the drafting of the figures. Mr. W. Talbot made available his equipment for photographing the ammonites.

A graduate teaching assistantship and a summer session bursary were provided by the Department of Geology during the writing of the thesis.

I would also like to personally thank Mr. G. Milvain for courtesies extended. My wife, Linda, typed the final manuscript. I would also like to take this pleasant opportunity to thank her for her encouragement and patience during the preparation and writing of the thesis.

TABLE OF CONTENTS

ABSTRACT.....	i
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES.....	vii
CHAPTER ONE - INTRODUCTION.....	1
The Project.....	1
Sample Collection.....	2
Sample Processing.....	2
Sample Designation and Preservation of Types.....	5
CHAPTER TWO - STRATIGRAPHY.....	8
Introduction.....	8
Location of Samples.....	10
The Fort St. John Group.....	10
Paleogeography.....	18
Lithology and Paleontology of the Moberly Lake Section.....	19
Depositional Environment.....	20
Previous Correlations.....	21
Age.....	23
CHAPTER THREE - COMPARISONS, PALEOECOLOGY AND CONCLUSIONS.....	26
Comparisons with Microfaunal Assemblages in Canada.....	26
Comparisons with Microfaunal Assemblages in the United States.....	27
Paleoecology.....	30
Conclusions.....	30

CHAPTER FOUR - FORMAL TAXONOMIC DESCRIPTIONS.....	33
Introduction.....	33
Family Astrorhizidae Brady, 1881.....	34
Genus <u>Bathysiphon</u> Sars, 1872.....	34
Family Saccamminidae Brady, 1884.....	35
Genus <u>Saccamina</u> Sars, 1869.....	35
Family Ammodiscidae Reuss, 1862.....	41
Genus <u>Ammodiscus</u> Reuss, 1862.....	41
Genus <u>Glomospira</u> Rzehak, 1885.....	43
Family Hormosinidae Haeckel, 1894.....	44
Genus <u>Reophax</u> Montfort, 1808.....	44
Family Rzehakinidae Cushman, 1933.....	46
Genus <u>Miliamina</u> Heron-Allen and Earland 1930.....	46
Genus <u>Psamminopelta</u> Tappan, 1957.....	50
Family Lituolidae de Blainville, 1825.....	52
Genus <u>Trochamminoides</u> Cushman, 1910.....	52
Genus <u>Haplophragmoides</u> Cushman, 1910.....	53
Genus <u>Ammobaculites</u> Cushman, 1910.....	58
Family Textulariidae Ehrenberg, 1838.....	61
Genus <u>Textularia</u> DeFrance, 1824.....	61
Family Trochamminidae Schwager, 1877.....	64
Genus <u>Trochamina</u> Parker and Jones, 1859.....	64
Family Ataxophragmiidae Schwager, 1877.....	70
Genus <u>Verneuilina</u> d'Orbigny, 1839.....	70
Genus <u>Verneuilinoidea</u> Loeblich and Tappan, 1949.....	71
Genus <u>Tritaxia</u> Reuss, 1860.....	75
Genus <u>Gaudryina</u> d'Orbigny, 1839.....	76

	vi
Subclass Radiolaria Muller, 1858.....	77
Genus <u>Dictyomitra</u> Zittel, 1876.....	77
Incertae sedis.....	78
Fecal pellets?.....	78
REFERENCES CITED.....	79
APPENDIX A - LITHOLOGIC SUMMARY.....	89
APPENDIX B - NOTE ON PEACE RIVER NOSING.....	93
EXPLANATION OF PLATES.....	94

LIST OF FIGURES

Figure 1	Location Map.....	3
Figure 2	Geology of Collecting Locality.....	4
Figure 3	Correlation Chart.....	24
Figure 4	Distribution, Percentage of Specimens and Number of Species per Sample.....	28
Figure 5	Published Ranges of Forms Occurring in Thesis Section.....	29
Text Figure	Specimen Mount.....	6

CHAPTER ONE -- INTRODUCTION

The Project

This thesis describes the microfauna of the lower Neogastrolites zone of the Cretaceous Fort St. John Group of the Moberly Lake area of northeastern British Columbia. Although the ammonites have been known for many years, the apparently poisonous nature of the bottom of this ancient land-locked sea prevented a benthonic fauna from developing. Therefore only the nektonic elements were known. The sandy margins, as represented by formations such as the Goodrich and Sikanni, carry a benthonic molluscan fauna but because of the coarse clastic nature of the containing rock the microfauna is recovered with difficulty. The writer has selected a section near the pinchout of the Goodrich Sand where the finer clastics permit recovery of the benthonic foraminifers and at the same time enough of the ammonite fauna to recognize the zonal position of the strata.

There is a concentration of silt and fish remains within the Cretaceous Colorado Shales in the subsurface of western Canada and the United States called the Fish Scale Marker Bed, which is used to mark the Upper-Lower Cretaceous boundary. Inasmuch as there might be an unconformity in connection with the fish scales (Patterson, 1970; p.58) it is important that workers be able to recognize various micro-

faunal assemblages from strata subjacent to the marker bed. Two pre-Fish Scale Marker microfaunas, the Haplophragmoides gigas fauna and the Miliammina manitobensis fauna are already known from the lower part of the Colorado Shale but have no ammonite control. Ammonites are known from the middle part of the Colorado Shale, mainly neogastropplitids and acanthoceratids, while the post-Fish Scale Marker microfaunas have been dealt with previously (Stelck, Wall and Wetter, 1958). The microfaunal suite discussed in this thesis ties into the Fish Scale Marker Bed and is above the Miliammina manitobensis zone. It is hoped that this assemblage will prove to be of correlative value where similar facies of the Lower Colorado Shale are found.

Sample Collection

The samples were collected by C.R. Stelck and G.D. Williams in September 1968 and by the writer in September 1969 from roadcuts along the highway between Moberly Lake and Hudson Hope in northeastern British Columbia. The sampled strata occur in the Lower Cruiser, Goodrich and Upper Hasler Formations (See figures 1,2).

Sample Processing

About one hundred grams of each sample were washed and placed in a labelled sealer jar, which was filled with water. These were wet sieved using the mesh sizes 40, 60, 80, 100, 120, and pan. The material on the 40 mesh sieve usually con-

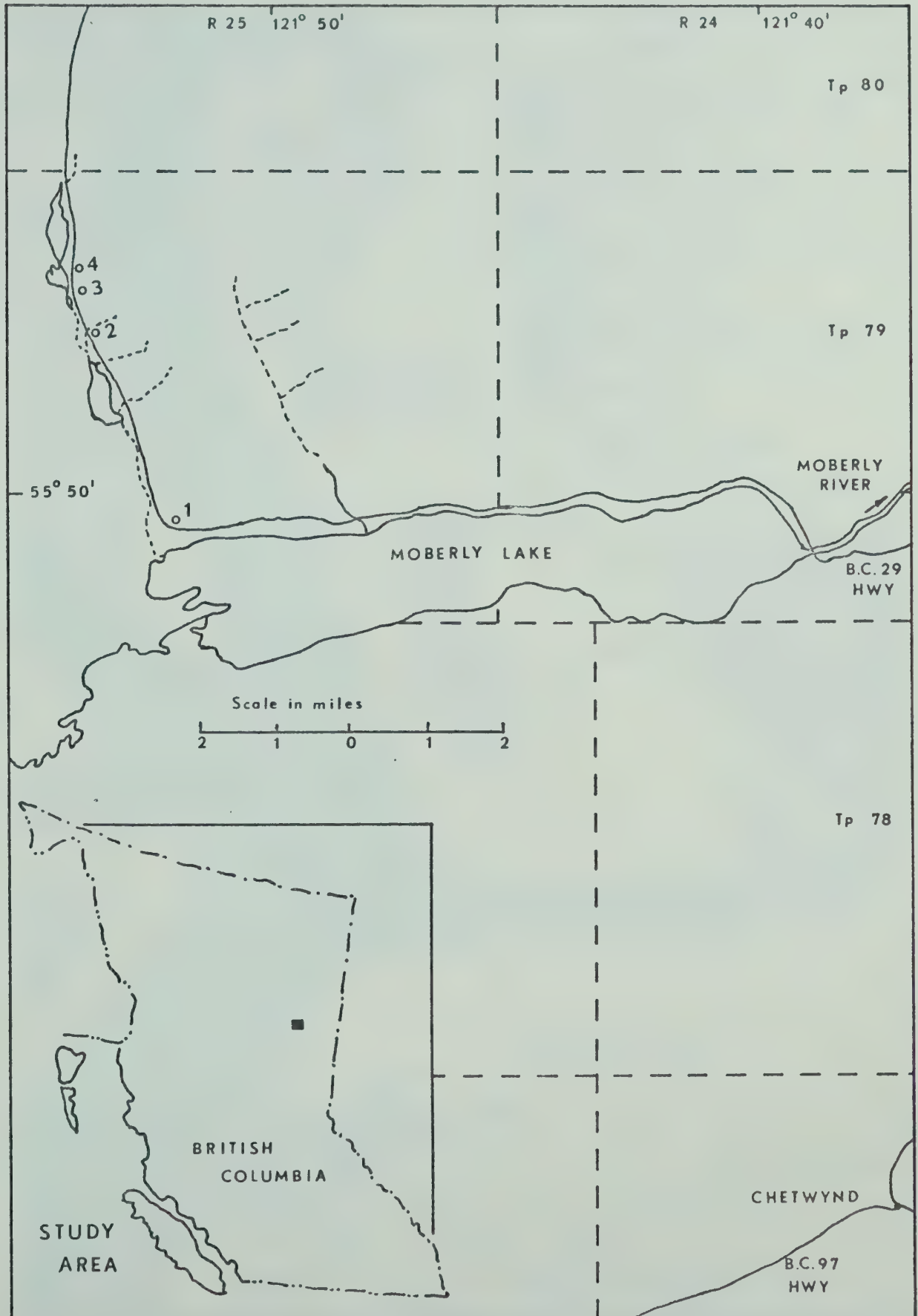


Figure 1 Location of Outcrop Samples, Goodrich and Cruiser Formations
Northeastern British Columbia

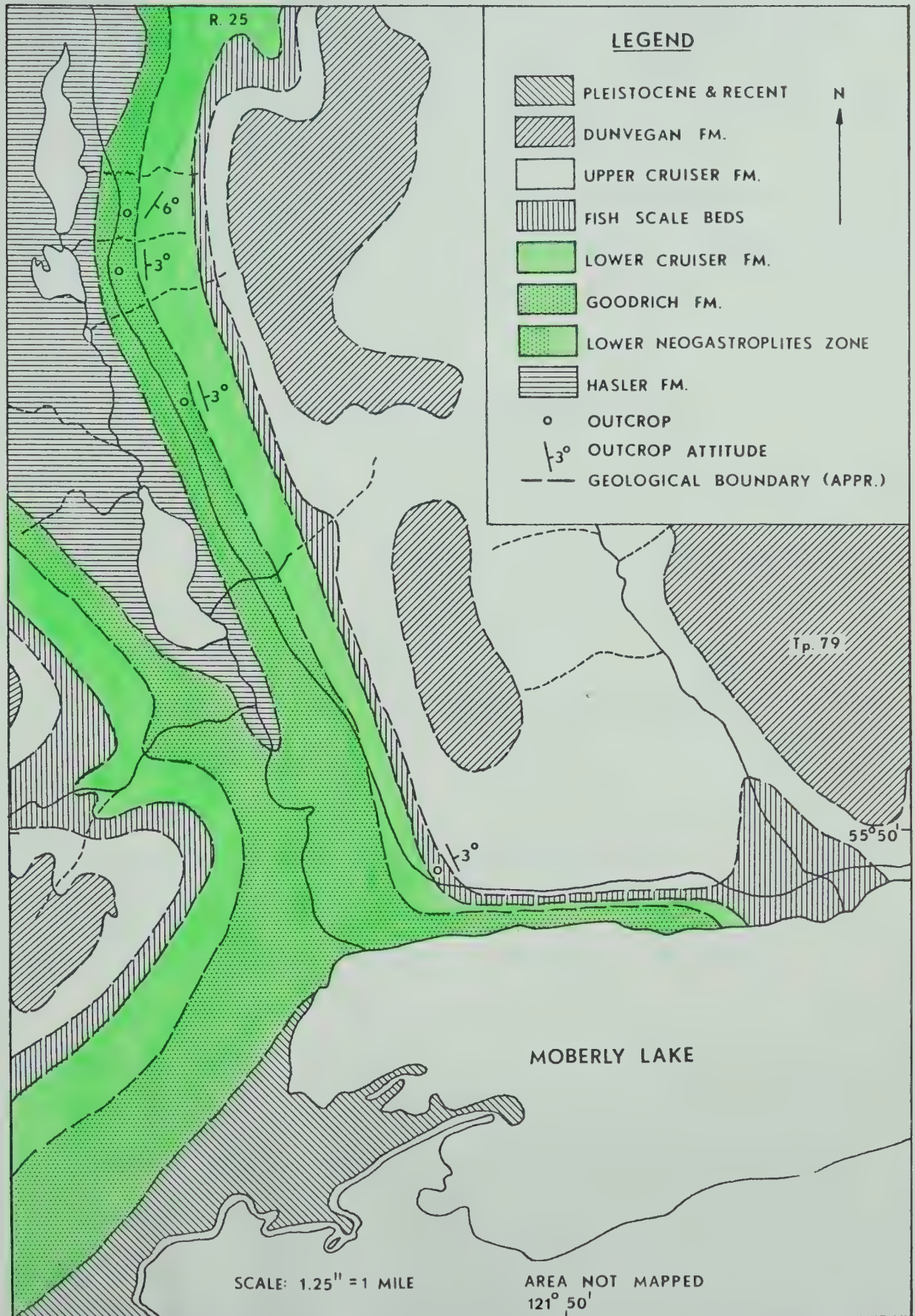


Figure 2 Geology of Collecting Locality (Geology after Stelck, personal communication)

sisted of aggregates of material. This material was broken down by boiling in water with Quaternary "O" (detergent) added and then wet sieved again. The various sized fractions were then dried and picked for foraminifers.

Frequency has been rated on the following scale: single (1 specimen), rare (2 to 5 specimens), common (6 to 14 specimens) and abundant (15 or more specimens).

Sample Designation and Preservation of Types

Coding of samples is as follows: eg. G3-10-2

The first letter is the general collection designation. The first number means that the specimen is from outcrop number three. The second figure indicates footage above (+) or below (-) the top of the Goodrich Sandstone. The last number indicates that the figured type is located in slide two of the type collections.

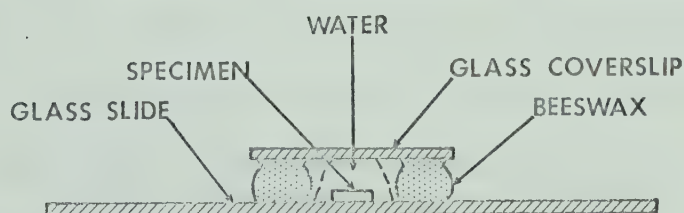
The collection sites are shown in figure 1. All holotypes and figured types are housed in the paleontology collections of the University of Alberta, Edmonton.

Photomicrography

In the past published photomicrographs of foraminifers have not been very clear. The main problem is that the specimens reflect too much light. This gives a picture which is too bright and the details are blotted out or, if the light is reduced, the picture is too dark and again the

details are obscure. The usual practice in examining foraminifers is to wet them with water which makes the internal details visible. Internal detail is also lost in most photomicrographs.

The following method for mounting the specimens in water has been devised in order to eliminate some of these problems. A beeswax ring, with approximately 5 mm. inside diameter and twice the height of the specimen, was made on a glass slide which had been placed on a warm hotplate. The specimen was placed in the center of the wax ring and a drop of water added. It is important to insure that the top of the water meniscus is even with the top of the wax ring or a "foggy" slide will result when it is sealed (See text figure).



To make the slide semi-permanent a cover slip is added. It is sealed by first sticking it down with a very small amount of clear nail polish; then by putting the inverted slide on a warm hotplate the wax is allowed to melt and make a permanent bond. When sealing the coverslip the hotplate must not be too hot or the heated water will burst through the melted wax. This method of mounting is semi-permanent and slides do

not dry out for several months. The specimen is also easily recovered for permanent storage.

The water distributes reflected light evenly over the specimen and eliminates the problem of having bright spots which cause loss of detail on the prints. Light for the photomicrographs is supplied by two variable intensity lamps, one on each side of the specimen. A third light is used to supply low intensity transmitted light which helps to bring out detail by shortening the exposure time. The best quality photomicrographs are achieved by having the intensity of the reflected light lower than is required for optimum viewing through the microscope. The chambers of some specimens are filled with opaque material and very effective photomicrographs result when only transmitted light is used.

All photomicrographs have been taken by an Orthomat microscope camera on Adox KB 14 film and printed on Kodak Kodabromide F-3 single weight paper. Where drawings have been used to supplement detailed interpretations, they were added directly to the final plate assembly.

CHAPTER TWO -- STRATIGRAPHY

Introduction

The Neogastrolites zone is a mid-Cretaceous biostratigraphic unit which is apparently geographically restricted to the interior part of the North American continent. It spans the Lower Cretaceous - Upper Cretaceous boundary but because of the endemic nature of the contained fauna, correlation with the European zonal sequence has been difficult. Therefore it has been necessary to integrate a composite succession from the Canadian and American local faunas.

The genus Neogastrolites was first defined by McLearn (1931, p.7) from a specimen collected by Selwyn in 1875 from the upper part of the Fort St. John Shale on the north side of the Peace River between the mouth of Cache Creek and a little below old Fort St. John. The lectotype was chosen by McLearn from specimens described by Whiteaves (1885, p.239) as Buchiceras? cornutum. This species was used as genus type for Neogastrolites. McLearn (1933, p.24) proposed a new species, N. selwyni, for a form in which the tuberculation was reduced and the ribs closer together when compared to N. cornutus. The relative stratigraphic position of these two species, however, was not known.

A zonal succession based on American collections of Neogastrolites from the Mowry Shale of the western interior of the United States was proposed in 1960. Reeside and

Cobban (1960) used a Neogastrolites sequence of the following five species in descending order:

Neogastrolites maclearni

Neogastrolites americanus

Neogastrolites muelleri

Neogastrolites cornutus

Neogastrolites haasi

Warren and Stelck in 1958 had already recognized a later sequence of neogastrolitids with such forms as Beattonoceras, Irenicoceras and Neogastrolites septimus, but these were not recorded from the Montana - Wyoming sections in the monograph on Neogastrolites by Reeside and Cobban (1960). An integration of the combined Canadian and American successions seems to give the following sequence of eight neogastrolitids in northeastern British Columbia (Warren and Stelck, 1969, p.530).

Beattonoceras beattonense

Irenicoceras bahani

Neogastrolites septimus

Neogastrolites maclearni

Neogastrolites americanus

Neogastrolites muelleri

Neogastrolites cornutus (See pl.6, fig.1)

Neogastrolites haasi (See pl.6, fig.4)

The foraminifers described in this thesis are recovered from the Neogastrolites muelleri, N. cornutus and N. haasi zones, collectively termed the lower Neogastrolites zone, from the

Fort St. John Group of Moberly Lake area of northeastern British Columbia.

Location of Samples

The section sampled for this thesis (See figure 1) is located about fifty miles west of the type section of both the Fort St. John Group and of the original collecting locality of N. cornutus. The type section is, however, a deeper water facies; although it has yielded many ammonites, very few foraminifers have been recovered. Therefore the thesis suite is actually the most extensive suite of foraminifers closest to the type section of N. cornutus. In the Moberly Lake area N. haasi occurs below the Goodrich Sandstone and elements of the N. cornutus fauna occur within the Goodrich Sandstone tongue of the Fort St. John Shales.

The Goodrich tongue is a thin pinchout margin of the 500 feet thick type Goodrich Formation which lies eighteen miles to the south. The pinchout remnant correlates with the uppermost sands of the type Goodrich. In the type section the Goodrich consists of nine marine sandstone members lying above the Hasler Shale Formation and below the Cruiser Shale Formation which are both part of the Fort St. John Group.

The Fort St. John Group

The name Fort St. John was originally used by Dawson (1881) for the "Lower dark shales" as described by Selwyn (1877), of the Peace and Pine River valleys. The upper

limit was placed at the base of the "Lower sandstones and shales", that is the base of the Dunvegan Formation, while the lower limit is the top of the Gates Sandstone Formation (McLearn and Kindle, 1950, p.73). McConnell (1893) examined a continuation of these shales on the Peace River below Smoky River. He defined the Fort St. John Formation as those shales lying under the Dunvegan Formation and on the Peace River Formation. The Fort St. John Formation was changed to St. John Formation and extended by McLearn (1918, p.17) who stated:

"The St. John formation, as here interpreted, embraces all the strata lying between the Bull Head Mountain below and Dunvegan sandstones above. It consists of two thick shale members separated by a thin sandstone member."

McLearn (1932), however, reverted to using Fort St. John Formation and redefined it to include shale beds only between the Gates Formation and the Dunvegan Formation.

From work in the Mount Hucross-Commotion Creek area of northeastern British Columbia, Wickenden and Shaw (1943, p.3) stated:

"... in this area ... there are five distinct formations, chiefly of marine origin, between the Bullhead and Dunvegan. Rather than attempt to correlate any or all of these with the St. John Formation as previously defined, it seems advisable to redefine the term as a group name to include all these predominantly marine strata."

Wickenden and Shaw included the following formations in descending order in the Fort St. John Group; Cruiser, Goodrich, Hasler, Commotion and Moosebar. A partial stratigraphic sequence for northeastern British Columbia has been outlined by Stott (1968a, p.3, 1968b, p.8) and is summarized as follows:

	Pine R. area	Sikanni Chief R.	Peace R., Alberta
	Dunvegan Fm.	Dunvegan Fm.	Dunvegan Fm.
Fort St. John Group	Cruiser Fm.	Sully Fm.	
	Goodrich Fm.	Sikanni Fm.	Shaftesbury Fm.
	Hasler Fm.		
	Commotion Fm.	Buckinghorse Fm.	Peace River Fm.
	Moosebar Fm.		Spirit River Fm.
	Gething Fm.	Gething Fm.	Gething Fm.
Bullhead Group	Cadomin Fm.		

In this thesis the microfauna have been collected from the Lower Cruiser, Goodrich and Upper Hasler Formations.

The Hasler Formation was first defined by Wickenden and Shaw (1943, p.6) as the shale beds overlying the Commotion Formation. They, however, did not specify a type section. To correct this Stott (1968b, p.89) designated the type section as "that occurring in a small stream flowing westward from Dokie Ridge into a tributary of Moberly River." In the type section the Hasler Formation is composed of two lithofacies. The basal one is predominantly siltstone with interbedded shale while the upper one is rubbly shale. The Hasler Formation lies on the Commotion Formation and in the type

section the base is marked by a layer of pebbles in a shaly matrix. The upper contact with the Goodrich Formation is gradational from shale to sandstone.

No fossils have been found in the type section of the Hasler Formation. Near the Peace River canyon, however, the Gastrolites fauna has been obtained from the lower beds of the expanded Hasler Formation (Stott, 1968b, p.93). At the type locality of the Goodrich Formation the Hasler contains a thin conglomerate stringer, above which, the shale carries Miliammina manitobensis Wickenden.

Wickenden and Shaw (1943, p.7) defined the Goodrich Formation as those sandstones lying between the Hasler and Cruiser Shales. The type section occurs on the first eastern tributary of Boulder Creek on the upper Pine River. All the formation does not outcrop here, so Stott (1968b, p.94) proposed a standard section be established at Dokie Ridge. The Goodrich Formation in type section consists of a series of nine sandstone units with interbedded shale. The contact with the underlying Hasler Formation is gradational but is drawn at the base of the lowest massive sandstone. The upper contact of the Goodrich with the Cruiser Formation is abrupt in the type section but is gradational in other localities.

Stott (1968b, p.98) reports the following fauna from the Goodrich Formation:

Bryozoan, genus and species indet.

Anomia sp. indet.

Arctica sp. indet.

Modiolus (Brachidontes) ex. aff. M. fulpensis

Stevenson

Modiolus sp.

Ostrea sp. indet.

Pholadomya? sp. indet.

Posidonia nahwisi (McLearn) var. goodrichensis

(McLearn)

Posidonia cf. P. nahwisi (McLearn) var.

goodrichensis (McLearn)

Pteria (Oxytoma) cf. P. camselli McLearn

Pteria (Oxytoma) cf. P. pinania McLearn

Tellina? sp. indet.

Protelliptio cf. P. hamili (McLearn)

Gastropod, genus and species indet.

Other species which were reported by McLearn and Kindle (1950, p.82) from the Goodrich Formation are:

Pleuromya kissoumi

Tancredia stelcki

Pleuromya wickendeni

Lucina? goodrichensis

Warren and Stelck (1969, p.539) reported Neogastrolites haasi in the Goodrich Sandstone 350 feet above the base in the type area, just above the collecting horizon for Posidonia goodrichensis. Neogastrolites cornutus was reported from the top of the Goodrich equivalent on the lower Pine River.

The name "Cruiser" was first used by Wickenden and Shaw (1943, p.8) for the dark grey shale and sandstone which over-

lies the Goodrich Formation and underlies the Dunvegan Formation. Stott (1968b, p.100) proposed a section on a small tributary on the south side of the Pine River, approximately one mile east of Young Creek, as the type section. The lower boundary of the Cruiser Shale in some areas is distinct where shale turns to sandstone, but is gradational in others. The upper boundary is usually gradational where Dunvegan Sandstone rests on Cruiser Shale. The Fish Scale Marker Bed occurs within the Cruiser Formation and is used to divide it into lower and upper parts.

Warren and Stelck (1969, p.535) reported the following fauna from the lower part of the Cruiser Formation:

" A single nodule U.A. 1104 collected from the basal 30 feet of the Cruiser just above the Goodrich equivalent near old Fort St. John, B.C. (the type locality of N. cornutus) included N. cornutus cornutus var. A, var. B, var. D, and var. E-F along with Posidonia nahwisi and marine reptile bones. Another nodule from the same interval included var. F. A topotype (U.A. 40825)" (See Pl.6, fig.1) "most closely resembling the lectotype of N. cornutus included in Var. E by Reeside and Cobban has been collected by Stelck from 108 feet below the fish scale marker bed, i.e., within the basal 20 ft. of the shales overlying the Goodrich equivalent."

Neogastrolites americanus has been reported from 100 feet above the top of the Goodrich Sandstone by Warren and Stelck (1969, p.539).

To the south and to the east the Goodrich Sandstone grades into shale (Stott, 1960, 1961a, 1961b, 1968b). At this point the Hasler Formation becomes inseparable from the overlying strata, and equivalent beds of the Hasler, Goodrich and Cruiser Formations are included in the Shaftesbury Formation.

McLearn and Henderson (1944, p.3) proposed the name "Shaftesbury" for the dark marine shales lying between the Peace River and Dunvegan Formations in the eastern part of the Peace River district. These shales were previously called the Fort St. John Formation (McLearn 1918, 1932). The type area of the Shaftesbury Shale was described as being along the Peace River valley between Dunvegan and the town of Peace River in Alberta.

No molluscan fossils have been found in the type section of the Shaftesbury. McLearn and Henderson (1944, p.3) reported a fragmentary specimen from the upper part of these shales in the Lone Mountain-Story Lake area of British Columbia which "may belong to the species Neogastrolites cornutus (Whiteaves)." In the Two Lakes area of Alberta Greiner (1955, p.4) also reported a specimen of Neogastrolites. Thorsteinsson (1952, p.30) reported Neogastrolites maclearni from the Shaftesbury Shales of the Cache Creek area while Irish (1955) reported Neogastrolites americanus from the same shales in the Adams Lookout area. Stelck (1962, p.10) reported Neogastrolites americanus and Neogastrolites aff. N. maclearni from "the fish-scale sands of the Shaftesbury Formation."

From the type section of the St. John Shale, as described by Dawson (1881), Stelck, Wall and Wetter (1958, pp.20,21) reported the following extensive suite of megafauna and microfauna from the equivalents of the upper Cruiser Shale:

Between 380 and 300 feet above the base of the Fish Scale Marker Bed:

a. Megafauna

Beattonoceras beattonense Warren and Stelck

b. Microfauna

Haplophragmoides sp.

Miliammina sp. A

Miliammina sp. B?

Between 300 and 160 feet above the base of the Fish Scale Marker Bed:

a. Megafauna

Irenicoceras bahani Warren and Stelck

Beattonoceras ontkoi Warren and Stelck

Neogastrolites septimus Warren and Stelck

Metasigaloceras?

Forbesiceras sp. A

Inoceramus irenensis Warren and Stelck

b. Microfauna

Gaudryina cf. G. hectori Nauss

Hippocrepina sp. A

Trochammina sp.

From the base of the Fish Scale Marker Bed to 160 feet above the base:

a. Megafauna

Neogastrolites sp.

Acompsoceras? sp.

b. Microfauna

Ammobaculites sp.

Haplophragmoides sp. A

Haplophragmoides sp. B

Miliammina sp. A

Miliammina sp. B

Reophax sp.

Microforaminifer "Gumbelina" (= Heterohelix)

Microforaminifer "Globigerina"

Stelck (1950, p.20) lists an extensive suite of foraminifers from the Neogastrolites zone.

Paleogeography

Epicontinental seaways prevailed during the Early Cretaceous epoch in western Canada and the central United States. In western Canada and the western interior of the United States the rocks are part of a long, wide belt which extends from the Arctic region to eastern Mexico. Cobban and Reeside (1952), Stelck (1958), Reeside and Cobban (1960), Wulf (1962) and Rudkin (1964) give accounts of the pattern of seaways and deposition.

Wulf (1962, p.1412) shows the maximum extent of the Colorado-Mowry sea. Wulf suggests it extended as far south as northern Utah and Colorado. Laterally it extended from eastern North and South Dakota to eastern Idaho and western Montana. In Canada it stretched from western Manitoba to

western Alberta in the south to northeastern British Columbia, southern Yukon and western Northwest Territories in the north. The seaway was probably separated from the boreal sea most of the time as the Neogastrolites fauna is endemic. In northeastern British Columbia the seaway was influenced by the Peace River nosing (See Appendix B) as both the Goodrich and Sikanni Sands pinch-out as the nosing is approached (Warren and Stelck, 1969).

Wulf (1962) felt that the Colorado-Mowry sea did not connect with the Gulf Coast. Eicher (1965, p.875), however stated:

"Calcareous planktonic specimens from the upper portion of the underlying Mowry Shale indicate that the boreal and Gulf Coastal seas actually connected in latest Mowry time."

Lithology and Paleontology of the Moberly Lake Section

The Cruiser Formation in the sampled section consists of shale. The Goodrich Sandstone pinchout is made up of two sandstone units, herein called the lower and upper sandstone units respectively, separated by a small shale interval. Stelck (personal communication) reports finding Posidonia nahwisi nahwisi, Neogastrolites sp. indet. and star fish trails in the Goodrich Formation at this site. The underlying Hasler Shale Formation has several ironstone nodule beds from one of which the writer has collected Neogastrolites haasi. (See pl.5, figs.2,3,5). This nodule bed is located 120 feet below the base of the lower sandstone unit.

Depositional Environment

The fauna of the Hasler, Cruiser and Shaftesbury Shales indicates these formations were deposited in a marine environment. Such genera as Gastroplites, Neogastroplites and Inoceramus testify to the marine nature of the sediments. In the thesis section, Neogastroplites haasi was recovered from the upper Hasler Formation while Warren and Stelck (1969) reported Neogastroplites from both the Goodrich and Cruiser Formations. The endemic nature of Neogastroplites suggests that the Colorado-Mowry sea was almost completely landlocked and may have been isolated from the major oceans of the world at times. It appears the seaway was open to the Gulf coast in latest Albian time (Eicher, 1965).

The Goodrich Sandstone is marine and probably represents a nearshore deposit (Stott, 1968b, p.113). From a thickness of 1320 feet at the standard section on Dokie Ridge, the Goodrich Formation thins to the northeast where the lower sandstone units pinch out before the upper ones, as the Peace River nosing is approached. A similar situation exists for the Sikanni sandstones to the north of the Peace River nosing (Warren and Stelck, 1969, p.538).

The foraminifers collected from the lower Neogastroplites zone are exclusively benthonic arenaceous. The absence of both benthonic and planktonic calcareous foraminifers suggests that the water had less than normal salinity. The presence of such forms as Saccamina, Trochamina and Ammobaculites imply shallow marine conditions. The assemblage from the Goodrich Sandstone is more coarsely arenaceous than that

from the Hasler and Cruiser Shales which is in keeping with the changes of lithology.

Stelck, Wall and Wetter (1958, p.24) believe that:

"The accumulation of fish-scales ... (At the top of the Moberly Lake section) in this area (Fort St. John) implies the development of an euxinic condition within the inland sea ... The cessation of the expansion of the sea was marked by the condensed bioclastic accumulation... the fish-scale sand marker bed.."

Previous Correlations

McLearn (1944, p.3; 1945, p.7) reported the Neogastroplices fauna from the upper part of the Shaftesbury Formation on the Peace River below Hudson Hope. The earliest recorded Neogastroplices is from the Third Sikanni Sand of the type section and is referred to as N. haasi (Warren and Stelck, 1969, p.533). N. haasi has also been reported from 350 feet above the base of the Goodrich Formation (Warren and Stelck, 1969). In the western interior of the United States Reeside and Cobban (1960, p.27) report N. haasi from the upper part of the Thermopolis Shale.

Neogastroplices cornutus has been reported by Warren and Stelck (1969, p.535) from the following locations:

"U.A. 40834 a and b come from the top of the Goodrich Formation equivalent on the lower Pine River, Twp. 81, R.20, W.6, B.C. U.A. 38371 comes from the Satanah River from the

base of the Sully Formation. U.A. 40869 (var.E) comes from the Halfway River just below Cameron River from the topmost (Fourth) Sikanni sandstone member. A single nodule U.A.1104 collected from the basal 30 ft. of the Cruiser just above the Goodrich equivalent near old Fort St. John, B.C. (the type locality of N. cornutus) included N. cornutus cornutus var.A, var.B, var.D, and var.E-F along with Posidonia nahwisi and marine reptile bones. Another nodule from the same interval included var.F. A topotype (U.A. 40825) most closely resembling the lectotype of N. cornutus included in var.E by Reeside and Cobban has been collected by Stelck from 108 ft. below the fish scale marker bed, i.e. within the basal 20 ft. of the shales overlying the Goodrich equivalent."

Reeside and Cobban (1960, p.27) reported N. cornutus from the base of the Mowry Shale and from the middle of the Aspen Shale.

The most northerly occurrence of Neogastrolites is that of N. muelleri which was found on the Petitot River 400 to 500 feet below the Nelson Conglomerate (Warren and Stelck, 1969, p.538). They also reported it from the middle part of the shales between the top of the Goodrich equivalent and the Fish Scale Marker Bed (p.537). In the United States Reeside and Cobban collected N. muelleri from 40 feet above the N. cornutus assemblage in the Colorado Shale.

In northeastern British Columbia Warren and Stelck (1969, p.539) collected N. americanus from 100 feet above the top of the Goodrich Sandstone on the Pine River and also from 6 feet below the Fish Scale Marker Bed at Taylor Crossing on the

Peace River. In the western interior of the United States Reeside and Cobban (1960, p.27) show N. americanus occurring at the top of the Aspen Shale, the middle of the Mowry Shale and the lower part of the Colorado Shale 120 feet above N. muelleri.

Neogastrolites maclearni has been reported from 70 feet above the base of the Alberta Shale in the Cadomin area of Alberta. In addition Thorsteinsson (1952, p.30) collected N. maclearni from 217 feet above the base of the Alberta Shale in the Cache Creek area. In Montana Reeside and Cobban (1960) showed N. maclearni from the topmost beds of the Mowry Shale (See figure 3).

Wickenden (1945, p.22) reported Miliammina manitobensis from outcrops of the upper Ashville Formation. In comparison there is a conglomerate below both the type Sikanni and Goodrich Sandstones above which M. manitobensis occurs (Stelck, 1950). This zone is however below the section sampled by the writer (See figure 3).

Age

The lower Neogastrolites fauna occurs above the Gastrolites fauna but there is a considerable non-fossiliferous interval between these two faunas in western Canada. In England, however, Gastrolites is found in the top of the Middle Albian substage of the Gault Formation. The upper Neogastrolites fauna occurs below the Acanthoceras fauna and the latter occurs in the Cenomanian stage in England. Therefore the Neogastrolites zone has to lie between the

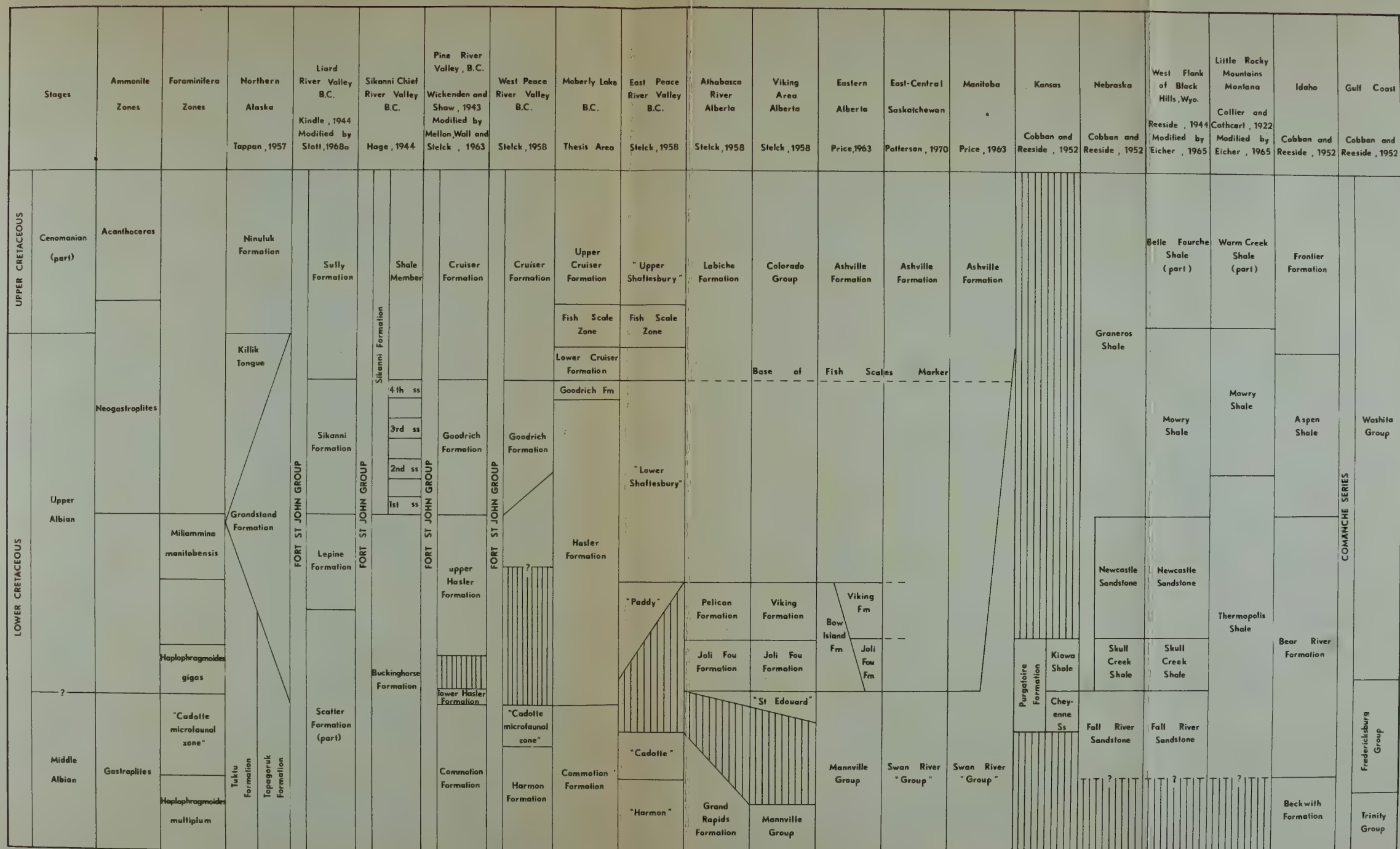


Figure 3; Correlation Chart

Modified from Cobban and Reeside 1952,
Reeside and Cobban 1960, Price 1963, Stelck
1958, and Mellon, Wall and Stelck 1963.

Middle Albian and the Middle Cenomanian. The Albian-Cenomanian boundary has been placed by Warren and Stelck (1969, p.533) within the fish scale bearing beds above the Fish Scale Marker Bed within the Neogastrolites zone. This would place the lower part of the Neogastrolites zone within the Upper Albian substage. Folinsbee, Baadsgaard and Cumming (1963, p.75) dated volcanic ash beds from the Mowry Shale of Wyoming and Montana and gave a date of 94 my. (million years) for N. maclearni, 96 my. for N. americanus and 98 my. for N. cornutus. In stratigraphic terms this puts the Upper-Lower Cretaceous boundary at slightly younger than 94 my. and the base of the Fish Scale Marker Bed at about 95 my. (Warren and Stelck, 1969, p.534). The suites dealt with in this thesis would range in age from about 97 my. to slightly older than 98 my. before present.

CHAPTER THREE -- COMPARISONS, PALEOECOLOGY and CONCLUSIONS

Comparisons with Microfaunal Assemblages in Canada

The lower Neogastrolites zone has the following foraminifers in common with the Shaftesbury Formation (pre-Fish Scale Marker Bed). Nielson (1950) reported Saccamina alexanderi, Psamminopelta bowsheri, and Verneuilioides perplexus from the lower Shaftesbury. Stelck, Wall and Wetter (1958) reported Saccamina sp. C from the upper Shaftesbury Formation. From the type Sikanni Formation Stelck (1950) reported Saccamina alexanderi and from above the fourth sand Trochammina wickendeni. Haplophragmoides postis was recovered from 205 feet above the Gates Formation in the St. John Shale (Stelck et.al., 1956) and H. postis subsp. A occurs throughout the lower Neogastrolites zone. Saccamina alexanderi and Saccamina sp. C range throughout the Moberly Lake section and have been reported from the Upper St. John Shale (Stelck, 1950; Stelck et.al., 1958) (See figure 4).

The following species occur in both the Lower Neogastrolites zone and the Cenomanian Lower Kaskapau Formation: Verneuilina alameda (Stelck, 1950); Saccamina alexanderi and Ammobaculites pacalis (Stelck and Wall, 1954); Trochammina wetteri and Verneuilioides perplexus (Stelck and Wall, 1955). Textularia gravenori occurs irregularly throughout the Moberly Lake section and in the central portion of the Kaskapau

Formation of Alberta (Stelck and Wall, 1955). Haplophragmoides hendersonense only occurs in two samples but also has been reported by Stelck and Wall (1955) from the mid Kaskapau Formation.

In Saskatchewan Saccamina alexanderi has been reported from the Joli Fou Formation (Guliov, 1967).

Comparisons with Microfaunal Assemblages in the United States

The Cretaceous Grandstand and Topagoruk Formations of Alaska have the following species, as reported by Tappan (1957, 1962), in common with the lower Neogastrolites zone: Bathysiphon brosgiei, Miliammina ischnia, Psamminopelta bowsheri and Trochammina umiatensis. (See figure 5)

The following species reported by Eicher (1965) from the Mowry Shale of the western interior of the United States are also found in the Moberly Lake section: Saccamina alexanderi, Miliammina ischnia and Psamminopelta bowsheri. The overlying Graneros Shale as studied by Eicher (1965) contains the following elements in common with the thesis section: Saccamina alexanderi, Ammodiscus planus, Miliammina ischnia, Psamminopelta bowsheri, Trochamminoides apricarius, Haplophragmoides gilberti, H. hendersonense, Textularia rioensis, Trochammina rutherfordi mellariolum, Verneuilina alameda and Verneuilinoides perplexus.

In the type Pepper Shale of the Woodbine Group of Texas the following species, as reported by Loeblich (1946), are also found in the lower Neogastrolites zone: Ammodiscus planus, Trochammina wickendeni and Verneuilinoides perplexus.

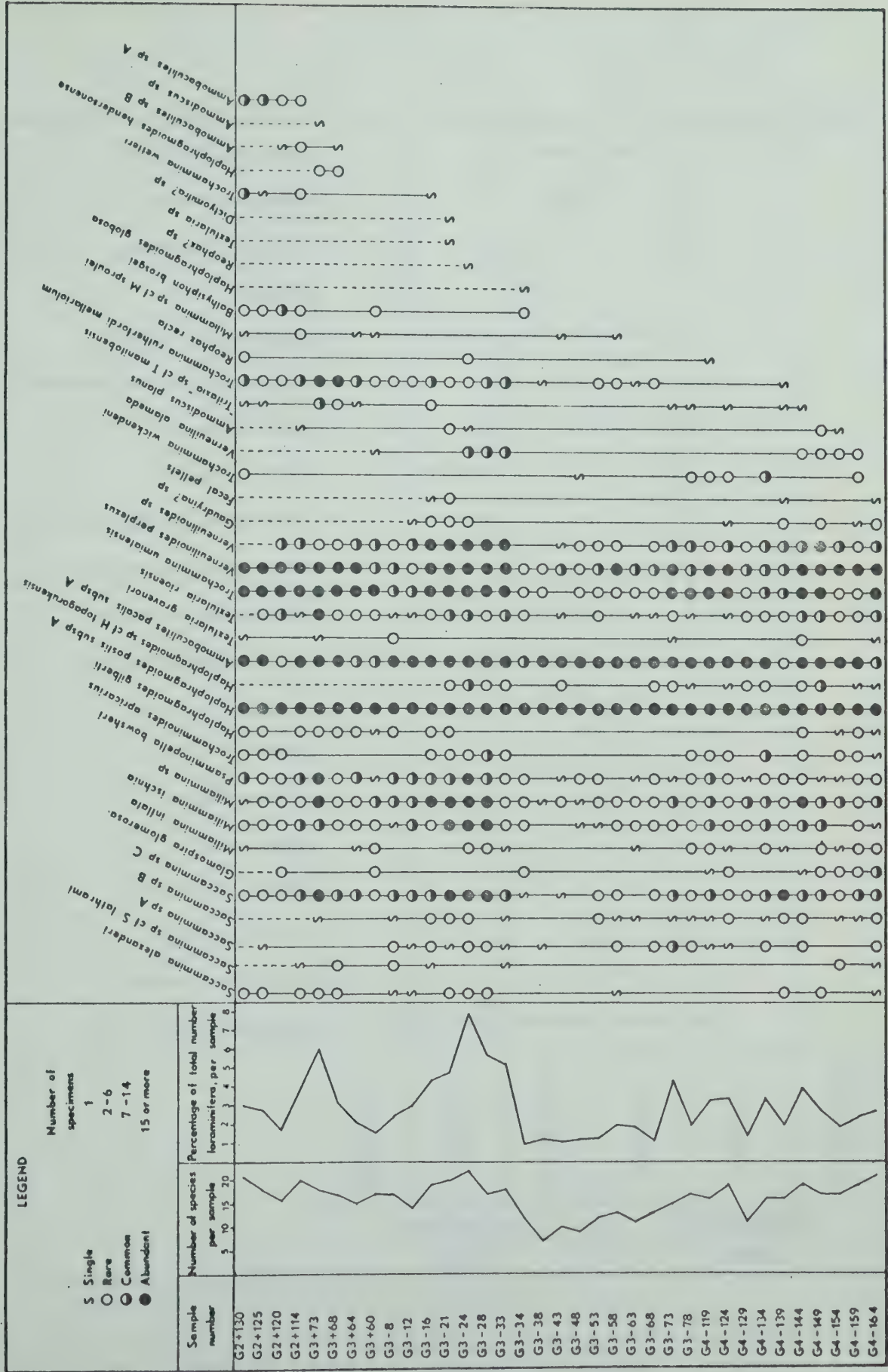


Figure 4: Distribution, Percentage of Specimens and Number of Species per Sample

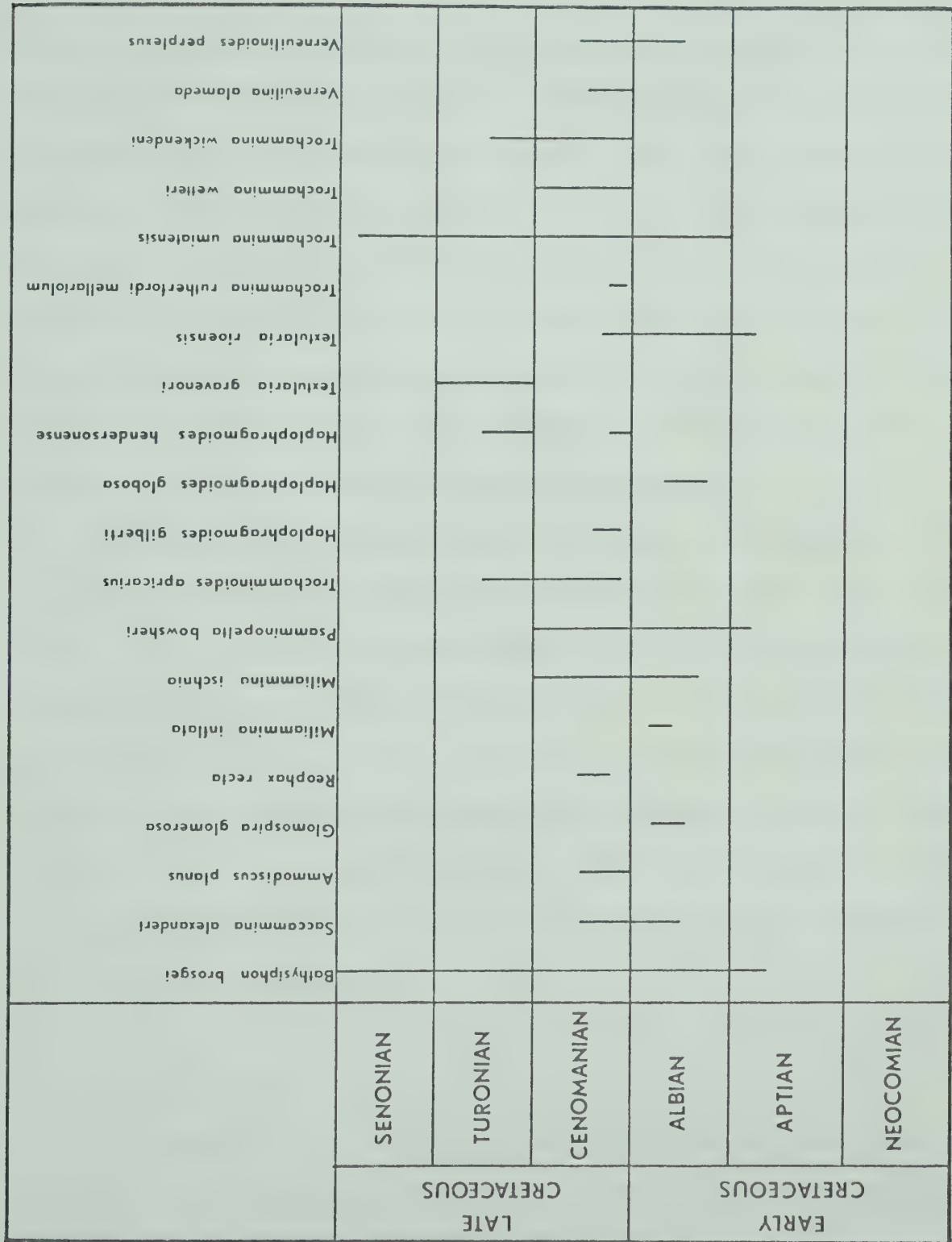


Figure 5: Published Ranges of Forms Occurring in Thesis Section

Paleoecology

The assemblage of foraminifers from the lower Neogastroplices zone is entirely arenaceous. This implies that the water was shallow at this time (Bandy and Arnal, 1960, p. 1925). The lack of calcareous species either planktonic or benthonic suggests that the water had slightly less than normal marine salinity (Eicher, 1965, p. 889). This is also supported by Wall (1967b, p. 181) who felt the water was shallow, cool, probably somewhat turbid and perhaps less saline than in a "normal marine" environment during late Albian time. "Normal marine" salinity did prevail though as evidenced by the presence of the remains of Neogastroplices.

The Goodrich Sandstone probably marks a lowering of the sea level with near shoreline conditions in the Moberly Lake area. The number of foraminifers per sample is greatly reduced during the time of deposition of the sand (See figure 4, G3-34 to G3-78). The specimens recovered from this sandy interval also tend to be composed of slightly coarser sand grains. This is a good indicator that the faunas recovered were in effect autochthonous to the sand bottom and not brought in by currents.

Conclusions

In the Moberly Lake section only the uppermost part of the Goodrich Formation (of type) is represented as Neogastroplices haasi occurs in the shale 202 feet below the top of the remnant Goodrich Sandstone. N. haasi has previously been reported from 350 feet above the base (approx. 250 feet below

the top) of the Goodrich (type area) (Warren and Stelck,1969). Elements of the N. cornutus assemblage have also been found in the Moberly Lake section of the Goodrich Sandstone (Stelck, personal communication). N. cornutus has been reported from the top of the Goodrich Formation equivalent on the lower Pine River (Warren and Stelck,1969). These records suggest that the upper Hasler Formation as seen in the Moberly Lake section represents a true interfingering of the shale-out of the lower Goodrich sands with the upper Hasler Shale.

The lower Shaftesbury Formation of Alberta is in part correlative to the thesis section with the following micro-fauna (Neilson,1950) in common: Saccamina alexanderi, Psamminopelta bowsheri, and Verneuilioides perplexus. The upper part of the Sikanni Formation and the lower part of the Sully Formation are correlative, with Saccamina alexanderi and Trochammina wickendeni in common, with the Moberly Lake section.

In the western interior of the United States the uppermost Thermopolis Shale and the Mowry Shale (in part) carry the lower Neogastrolites fauna, N. haasi and N. cornutus (Reeside and Cobban,1960). The following foraminifers reported by Eicher (1965) from the Mowry Shale; Saccamina alexanderi, Miliammina ischnia and Psamminopelta bowsheri, are common to the Moberly Lake section.

The upper part of the Cenomanian Graneros Shale of the western interior of the United States is characterized by the Trochammina rutherfordi mellarium zone (Eicher,1965). He also

found this zone in the upper part of the equivalent Belle Fourche Shale (Eicher, 1967). Along with T. rutherfordi mellariolum Eicher reported Ammodiscus planus and Haplophragmoides gilberti from that zone. Above the T. rutherfordi mellariolum zone, Eicher (1965) proposed the Trochamminoides apricarius zonule. These four species are all found in the lower Neogastrolites zone of the thesis. T. apricarius occurs throughout the zone and even below T. rutherfordi mellariolum. When the ammonites are considered these forms are much earlier in age than Eicher (1965) suggested. This suggests that these forms are facies controlled as both the lower Neogastrolites zone of the Moberly Lake area and the Graneros Shale (Eicher, 1965) were deposited in shallow water.

There was some marine connection with the Arctic coast during Shaftesbury time as the following forms reported by Tappan (1957, 1960) are in common with the Moberly Lake section: Bathysiphon brosgei, Miliammina ischnia, Psamminopelta bowsheri and Trochammina umiatensis. This could imply that the sea was open to the north at least intermittently during lower Neogastrolites time or that these forms could be residual from an earlier opening.

Below the type Sikanni Formation Stelck (1950) reported Miliammina manitobensis. This species was originally reported from the Lower Ashville Formation of Manitoba by Wickenden (1932). As the Goodrich Formation is correlative with the Sikanni Formation, the Moberly Lake section of the lower Neogastrolites zone is equivalent to the upper part of the Lower Ashville Formation.

CHAPTER FOUR - FORMAL TAXONOMIC DESCRIPTIONS

Introduction: For the arrangement of generic and higher ranked taxa the classification used by Loeblich and Tappan (1964) is followed. Details of the collecting locality and the code designation of samples are given in the Introduction. The Introduction also contains an explanation of sample preparation and photography techniques while the Appendix consists of a summary lithologic description.

Where possible the size range of a given species is based on fifty individuals, but should a smaller population be recovered, it is based on the total number of specimens available. An example of the range of diameter is 0.20 (0.30) 0.40 mm. where the first and last numbers represent the extremes and the bracketed number the average diameter.

Species represented by letters may represent new species but they have not been proposed as new at this time as they would not be valid. Also for some species insufficient numbers were recovered or they were too poorly preserved to be proposed as new.

Phylum PROTOZOA

Subphylum SARCODINA Schmarda, 1871

Class RETICULAREA Lankester, 1885

Subclass GRANULORETICULOSIA de Saedeleer, 1934

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Herouard, 1896

Superfamily AMMODISCACEA Reuss, 1862

Family ASTORRHIZIDAE Brady, 1881

Subfamily RHIZAMMININAE Rhumbler, 1895

Genus BATHYSIPHON M. Sars, 1872

BATHYSIPHON BROSGEI Tappan

Plate 1, figures 1,2

Bathysiphon brosgiei TAPPAN, 1957, U.S. Natl. Mus. Bull. 215, p.202, pl.65, figs.1-5. — Tappan, 1962, U.S. Geol. Surv. Prof. Paper 236-C, p.128, pl.29, figs,1-5. — Sliter, 1968, Univ. Kansas Paleontological Contrib., Art.7, p.39, pl.1, fig.1.

DESCRIPTION: Test small, compressed, slightly wrinkled, oval in cross section, chamber a single open tube with slight constrictions; wall very finely arenaceous, much cement; aperture simple, at end of tube.

DIMENSIONS: Length of specimen 0.53 mm.

Width of specimen 0.10 mm.

Range of width 0.10 (0.15) 0.20 mm.

DISTRIBUTION: B. brosgiei has previously been reported from throughout the Colville and Nanushuk Groups and the underlying Fortress Mountain Formation of Alaska (Tappan,

1957). Sliter (1968) reported it in the Rosario Formation (Campanian to Early Maestrichtian) of California.

REMARKS: Bathysiphon vitta is larger and has a smoother outer surface than this form. Twenty-eight specimens have been recovered for study.

FIGURED SPECIMEN: GS-58-1

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

Genus SACCAMMINA M. Sars, 1869

SACCAMMINA ALEXANDERI (Loeblich and Tappan)

Plate 1, figures 3,4

Proteonina 8-148-A STELCK, 1950, Unpublished Ph.D. Thesis, Stanford Univ., p.149, pl.2, fig.15.

Proteonina 16-56-A STELCK, 1950, Unpublished Ph.D. Thesis, Stanford Univ., p.154, pl.2, fig.21.

Proteonina 13-170-D STELCK, 1950, Unpublished Ph.D. Thesis, Stanford Univ., p.153, pl.5, fig.12.

Proteonina 31-290-A NIELSEN, 1950, Unpublished M.Sc. Thesis, Univ. Alberta, p.72, pl.2, fig.22.

Proteonina sp. STELCK et al., 1956, Res. Coun. Alberta Report No.75, p.47, pl.4, fig.8.

Proteonina 60C 160-165A CAMPBELL, 1956, Unpublished M.Sc. Thesis, Univ. Alberta, p.50, pl.1, fig.6.

Proteonina alexanderi LOEBLICH and TAPPAN, 1950, Univ. Kansas Paleont. Contrib. Protozoa, Art.3, p.5, pl.1, figs.1,2.

Proteonina cf. P. alexanderi Loeblich and Tappan. STELCK and WALL, 1955, Res. Coun. Alberta Report No. 70, p.52, pl.1, figs.5,6.

Saccammina alexanderi (Loeblich and Tappan). EICHER, 1960, Peabody Mus. Nat. Hist., Yale Univ., Bull.15, p.55, pl.3, figs.1,2. — CRESPIN, 1963, Aust. Bureau Min. Resources, Geol. and Geophy. Bull. No.66, p.20, pl.1, figs.10-12. — EICHER, 1965, Jour. Paleo., Vol.39, No.5, p.891, pl.103, fig.1. — EICHER, 1966, Contrib. Cushman Found. Foram. Res., Vol.17, Pt.1, p.20, pl.4, figs.1,2. — EICHER, 1967, Jour. Paleo., Vol.41, No.1, p.180, pl.17, fig.1.

Saccammina cf. alexanderi (Loeblich and Tappan). GULIOV, 1967, Sask. Depart. Min. Resources Report No.105, Pt.1, p.16, pl.1, fig.3.

DESCRIPTION: Test small, compressed; single bottle-shaped chamber with a prominent neck which is much thinner than the main part of test; wall composed of medium sized sand grains, much cement; aperture obscured, terminal at end of neck.

DIMENSIONS: Length of specimen 0.38 mm.

Width of specimen 0.20 mm.

Range of length 0.25 (0.33) 0.40 mm.

DISTRIBUTION: This species has been reported from the Buckinghorse Formation, Sikanni Formation and upper St. John Shale of northeastern British Columbia (Stelck, 1950); the basal Kaskapau Formation of Alberta (Stelck and Wall, 1954);

below the fish-scale zone of the Shaftesbury Formation of Alberta (Nielsen, 1950); the Cretaceous of the Cameron Hills, N.W.T. (Campbell, 1956); the Joli Fou Formation of Saskatchewan (Guliov, 1967); the Thermopolis, Skull Creek, Mowry, Carlile and Belle Fourche Shales of the western interior United States (Eicher, 1960, 1965, 1966, 1967); the type section of the Kiowa Shale of Kansas (Loeblich and Tappan, 1950) and the Lower Cretaceous Muderong Shale of Australia (Crespin, 1963). In the lower Neogastrolites zone the majority of the specimens occur above the lower sandstone unit.

REMARKS: The neck may begin very gradually or sharply and the specimens range from medium to coarsely arenaceous. The grains tend to be obscured in some specimens by the large amount of cement.

Proteonina arrasensis Stelck and Wall is similar to Saccamina alexanderi but lacks a definite neck. Proteonina difflugiformis (Brady) Cushman is identical in shape but is very coarsely arenaceous. Cushman (1946, p.15), however, states "The grains are very variable in size according to the material available for the construction of the test ..." Slama (1954, p.34) conducted experiments with modern agglutinated foraminifers in which he used different materials for a substrate. He concluded that "... the composition of the substratum was partially if not wholly responsible for producing individuals which would most certainly be recognized as new 'species' were it not for the known factor in their origin." Throughout the zones of shale in this section

there are lamina of fine-grained sandstone. It is felt that the more coarsely arenaceous forms of Saccamina alexanderi are closely associated with these zones.

A total of 48 specimens was collected for study.

FIGURED SPECIMEN: G3+73-2

SACCAMMINA sp. cf. S. LATHRAMI Tappan

Plate 1, figure 5

?Saccamina lathrami TAPPAN, 1960, Bull. Amer. Assoc. Pet.

Geol., Vol.44, No.3, Pt.1, p.289, figs.1,2. — TAPPAN, 1962, U.S. Geol. Surv. Prof. Paper 236-C, p.129, pl.29, figs.9-12. — GIVEN, 1969, Unpublished M.Sc. Thesis, Univ. Alberta, p.66, pl.1, fig.6.

DESCRIPTION: Test small, compressed; periphery round; single chamber, slightly depressed in center, much cement gives the surface a smooth finish; aperture simple, terminal at the end of a short neck.

DIMENSIONS: Length of specimen 0.33 mm.

Width of specimen 0.30 mm.

Range of length 0.25 (0.33) 0.44 mm.

DISTRIBUTION: Saccamina lathrami has previously been reported from the Torok, Topogoruk, Grandstand, Ninuluk and Seabee Formations of Alaska (Tappan,1957) and the Bearpaw Formation of Alberta (Given,1969). In this study seven specimens were recorded above the lower sandstone unit and three specimens near the bottom of the section.

REMARKS: Saccamina lathrami has a longer neck than this form. Saccamina sp. C. has no neck while Saccamina sp. B.

has no neck and is much larger.

FIGURED SPECIMEN: G3-8-3

SACCAMMINA sp. A

Plate 1, figures 6,7

DESCRIPTION: Test large, compressed; single bottle-shaped chamber with a neck which begins gradually; wall very coarsely arenaceous, much cement; aperture terminal at the end of neck, obscured.

DIMENSIONS: Length of specimen 0.75 mm.

Width of specimen 0.48 mm.

Range of length 0.38 (0.60) 0.90 mm.

DISTRIBUTION: Except for one specimen this form is found below the upper sandstone unit.

REMARKS: Saccamina alexanderi (Loeblich and Tappan) is distinct from Saccamina sp. A because of its much smaller size and its finer-grained wall. Proteonina? eurekaensis Stelck and Wall bears a striking similarity but lacks the definite neck.

Due to the poor preservation of some specimens it is difficult to tell if they belong to Saccamina or represent a broken off chamber of another form.

Forty-nine specimens have been recovered from the lower Neogastrolites zone.

FIGURED SPECIMEN: G3-28-4

SACCAMMINA sp. B

Plate 1, figure 8

DESCRIPTION: Test large sized, compressed; periphery oval; single oval chamber; wall medium to coarsely arenaceous; aperture not observed.

DIMENSIONS: Diameter of specimen 0.75 mm.

Range of diameter 0.45 (0.63) 0.78 mm.

DISTRIBUTION: Saccamina sp. B with the exception of one specimen is found below the upper sandstone unit.

REMARKS: This form varies from finely to coarsely arenaceous. Saccamina sp. C is one-third to one-half the size. Saccamina lathrami Tappan has a neck and is smaller than Saccamina sp. B.

Most of the 49 specimens have been compressed which gives some an oval periphery.

FIGURED SPECIMEN: G3-33-5

SACCAMMINA sp. C

Plate 1, figure 9

Saccamina sp. STELCK, WALL and WETTER, 1958, Res. Coun.

Alberta Bull.2, p.31, pl.4, fig.11.

Saccamina sp. C GIVEN, 1969, Unpublished M.Sc. Thesis, Univ. Alberta, p.69, pl.1, figs.7,8.

DESCRIPTION: Test small sized, compressed; periphery oval; single oval chamber, slightly depressed in the center; wall finely arenaceous, much cement gives the surface a smooth finish; aperture not observed.

DIMENSIONS: Diameter of specimen 0.25 mm.

Thickness of specimen 0.08 mm.

Range of diameter 0.17 (0.22) 0.30 mm.

DISTRIBUTION: Previously this form has been reported from the upper St. John shale, the basal Dunvegan sandstone and the upper Shaftesbury Formation of Alberta (Stelck, Wall and Wetter, 1958) and the Bearpaw Formation of Alberta (Given, 1969). It is, with the exception of two samples, found throughout the lower Neogastroplites zone.

REMARKS: Included with this form is a variant which is composed of medium sized sand grains. Some forms assignable to Pelosina appear somewhat similar to this but they possess an extension at both ends. Saccamina lathrami Tappan is also similar but possesses a neck.

Over three hundred specimens of this species have been recovered.

FIGURED SPECIMEN: G3+73-6

Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862

Genus AMMODISCUS Reuss, 1862

AMMODISCUS PLANUS Loeblich

Plate 1, figures 10, 11

Ammodiscus planus LOEBLICH, 1946, Jour. Paleo., Vol. 20,

No. 2, p. 133, pl. 22, fig. 2. — EICHER, 1965, Jour. Paleo., Vol. 39, No. 5, p. 892, pl. 103, figs. 2, 3.

DESCRIPTION: Test small; periphery round; chambers con-

sisting of a proloculus followed by a tubular, planispirally coiled second chamber which gradually increases in diameter and consists of seven whorls; suture spiral, distinct, slightly depressed; wall finely arenaceous, considerable cement; aperture round at end of coil, obscured.

DIMENSIONS: Diameter of specimen 0.23 mm.

Thickness of specimen 0.04 mm.

Range of diameter 0.20 (0.23) 0.28 mm.

DISTRIBUTION: Ammodiscus planus has been reported from the type Pepper Shale of Texas (Loeblich, 1946) and the Grangeros Shale of the western interior United States (Eicher, 1965). In this study the nine specimens are scattered throughout the section.

REMARKS: Ammodiscus rotularius Loeblich and Tappan differs from Ammodiscus planus as it has overlapping chambers and does not have depressed sutures. Ammodiscus cretaceous (Reuss) Cushman is larger, has more whorls and is partially involute. Ammodiscus kiowensis has fewer whorls and overlapping chambers.

FIGURED SPECIMEN: G4-192-7

AMMODISCUS sp.

Plate 1, figures 12, 13

DESCRIPTION: Test medium sized, crushed; periphery round, irregular; proloculus poorly defined; second chamber, tubular, planispiral, three whorls visible; suture spiral, distinct, depressed; wall finely arenaceous, much cement; aperture at end of coil, obscured.

DIMENSIONS: Diameter of specimen 0.30 mm.

Thickness of specimen 0.05 mm.

DISTRIBUTION: This species occurs as a single specimen 73 feet above the upper sandstone unit.

REMARKS: Ammodiscus planus is smaller and has twice as many whorls. As the central portion of the specimen is obscured by cement, it is not possible to tell the total number of whorls.

FIGURED SPECIMEN: G3+73-8

Genus GLOMOSPIRA Rzehak, 1885

GLOMOSPIRA GLOMEROSA Eicher

Plate 1, figures 14,15

Glomospira glomerosa EICHER, 1960, Peabody Mus. Nat. Hist., Yale Univ., Bull. 15, p.56, pl.3, fig.6.

DESCRIPTION: Test small; chamber broad, inflated, coil-
ed streptospirally; chamber increasing gradually in size;
suture distinct, slightly depressed; wall finely arenaceous,
much cement gives the surface a smooth finish; aperture
not observed, believed to be simple at end of chamber.

DIMENSIONS: Diameter of specimen 0.25 mm.

Thickness of specimen 0.13 mm.

Range of diameter 0.15 (0.23) 0.30 mm.

DISTRIBUTION: It has previously been reported from the
uppermost strata of the Shell Creek Shale of the western
interior United States (Eicher,1960); The majority of spec-
imens were recovered from the bottom 45 feet of the section.

REMARKS: Glomospira tortuosa Eicher can be distinguished from Glomospira glomerosa by its much rounder, tubular chamber and greater surface relief.

FIGURED SPECIMEN: G3+60-9

Superfamily LITUOLACEA de Blainville, 1825

Family HORMOSINIDAE Haeckel, 1894

Subfamily HORMOSININAE Haeckel, 1894

Genus REOPHAX Montfort, 1808

REOPHAX RECTA (Beissel)

Plate 1, figures 16,17

Reophax recta (Beissel).EICHER, 1967, Jour. Paleo., Vol.41, No.1, p.180, pl.17, figs.3,4.

DESCRIPTION: Test large sized, elongate, nodose, compressed; two chambers arranged uniserially; chambers inflated, first is round, second is slightly pyriform; suture distinct, strongly depressed; wall finely arenaceous, much cement gives the surface a smooth finish; aperture simple, round, at end of last chamber.

DIMENSIONS: Length of specimen 0.50 mm.

Width of specimen 0.30 mm.

Range of length 0.33 (0.43) 0.75 mm.

DISTRIBUTION: Eicher (1967) reported this species from the upper part of the Belle Fourche Shale of the western interior United States. The seven specimens, in this study, come from three randomly distributed samples.

REMARKS: Only a two-chambered form has been found which is similar to Eicher's (1967) figure 3. Eicher however found forms of which the chambers vary from two to six in number. As the specimens being studied here are from a more northerly sea, they may have had fewer chambers because of a harsher environment which may have limited the growth period.

FIGURED SPECIMEN: G4-157-10

REOPHAX? sp.

Plate 1, figure 18

DESCRIPTION: Test medium sized, elongate, compressed, four chambers arranged uniserially; first three chambers gradually increasing in size, last chamber four times the size of the previous chambers, strongly pyriform; sutures indistinct, straight, slightly depressed; wall coarsely arenaceous; aperture terminal, at end of a neck.

DIMENSIONS: Length of specimen 0.40 mm.

Maximum width of specimen 0.30 mm.

DISTRIBUTION: Only one specimen was found 24 feet below the top of the Goodrich Sandstone.

REMARKS: This specimen is incomplete and is missing some of the earlier chambers.

FIGURED SPECIMEN: G3-24-11

Family RZEHAKINIDAE Cushman, 1933

Genus MILIAMMINA Heron-Allen and Earland, 1930

MILIAMMINA INFLATA Eicher

Plate 2, figures 1,2

Miliammina inflata EICHER, 1960, Peabody Mus. Nat. Hist.,
Yale Univ., Bull.15, p.70, pl.5, figs.13,14.

DESCRIPTION: Test small, compressed; periphery subrectangular; inflated chambers arranged in quinqueloculine fashion; sutures distinct, depressed; wall finely arenaceous, much cement; aperture simple at end of last chamber, inconspicuous in most specimens, neck absent.

DIMENSIONS: Length of specimen 0.28 mm.

Width of specimen 0.18 mm.

Range of length 0.18 (0.28) 0.38 mm.

DISTRIBUTION: It was originally reported from the Haplophragmoides gigas zone of the Thermopolis Shale (Eicher, 1960). Guliov (1967) reported a similar form with a small neck from the Joli Fou Formation of Saskatchewan. Thirty-nine specimens occur irregularly throughout the lower Neogastrolites zone.

FIGURED SPECIMEN: G3-24-12

MILIAMMINA ISCHNIA Tappan

Plate 2, figures 3-5

Miliammina ischnia TAPPAN, 1957, U.S. Natl. Mus. Bull.215,
p.211, pl.67, figs.25,26. — TAPPAN, 1962, U.S. Geol.

Surv. Prof. Paper 236-C, p.160, pl.37, figs.1-5. — EICHER, 1960, Peabody Mus. Nat. Hist., Yale Univ., Bull.15, p.71, pl.5, figs.11,12. — EICHER, 1965, Jour. Paleo., Vol.39, No.5, p.893, pl.103, figs.4,5. — EICHER, 1966, Contrib. Cushman Found. Foram Res., Vol.18, Pt.1, p.21, pl.4, figs. 5,8. — GULIOV, 1967, Sask. Depart. Min. Resources Report No.105, Pt.1, p.21, pl.3, fig.2.

DESCRIPTION: Test small, compressed, elongate, sides slightly convex to nearly parallel; chamber arrangement quinqueloculine; chambers tubular, half coil in length; sutures distinct, slightly depressed; wall finely arenaceous, smoothly finished; aperture simple at end of last chamber, inconspicuous in most specimens, neck absent.

DIMENSIONS: Length of specimen 0.38 mm.

Width of specimen 0.13 mm.

Range of length 0.23 (0.35) 0.53 mm.

DISTRIBUTION: Miliammina ischnia has previously been reported from the Grandstand, Topagoruk and Chandler Formations of Alaska (Tappan, 1957) and from the Muddy Sandstone, Shell Creek, Skull Creek, Graneros, Mowry and Carlile Shales of the western interior United States (Eicher, 1960, 1965, 1966). In this study it is found throughout the section although it tends to be rarer through the lower sandstone unit.

REMARKS: Many of the specimens are crushed making identification difficult. Also included in this group are specimens having three-two and five-four chamber arrangements.

This form is distinguished from Miliammina manitobensis by its subparallel sides, lack of an apertural neck and smaller chambers. Over 180 specimens have been found throughout the section.

FIGURED SPECIMEN: G3+73-13

MILIAMMINA sp. cf. M. SPROULEI Nauss

Plate 2, figures 6-9

?Miliammina sproulei NAUSS, 1947, Jour. Paleo., Vol.21, No.4, p.339, pl.48, fig.13.

DESCRIPTION: Test medium sized, compressed, longer than broad; periphery elliptical; chambers elongate, slightly inflated, four visible on one side, three on the other, last two chambers are much larger than the earlier ones; sutures distinct, slightly depressed; wall finely arenaceous, much cement; aperture terminal on a neck.

DIMENSIONS: Length of specimen 0.40 mm.

Width of specimen 0.23 mm.

Range of length 0.25 (0.35) 0.43 mm.

DISTRIBUTION: Miliammina sproulei has been reported from the Cummings Member of the Mannville Formation; the lower Colorado Group of Alberta (Stelck et al., 1956); the basal one hundred feet of the Shaftesbury Formation of Alberta (Nielsen, 1950) and from the Joli Fou Formation of Saskatchewan (Guliov, 1967). All but two specimens were recorded from above the upper sandstone unit.

REMARKS: Most of the seven specimens recovered are

crushed and have a five-three chamber arrangement. Miliammina sproulei can be distinguished from this form by its quinqueloculine chamber development and shorter neck. Some of the specimens, such as the figured one, have a quinqueloculine chamber development but are poorly preserved.

FIGURED SPECIMEN: G3+64-14

MILIAMMINA sp.

Plate 2, figures 10-13

DESCRIPTION: Test medium sized, compressed, longer than broad; periphery lenticular; chamber arrangement quinqueloculine, chambers tubular, half coil in length; sutures distinct, slightly depressed; wall finely arenaceous, much cement gives the surface a smooth finish; aperture simple at end of last chamber, no neck visible.

DIMENSIONS: Length of specimen 0.40 mm.

Width of specimen 0.20 mm.

Range of length 0.28 (0.33) 0.50 mm.

DISTRIBUTION: Approximately 350 specimens have been found throughout the lower Neogastrolites zone.

REMARKS: In the assemblage the periphery varies from lenticular to oval. Also included is a variant which has five chambers on one side and four on the other.

The figured specimen of Miliammina awunensis Tappan is much more inflated while that of Miliammina ischnia is much narrower and has smaller chambers.

FIGURED SPECIMEN: G3+73-15

Genus PSAMMINOPELTA Tappan, 1957

PSAMMINOPELTA BOWSHERI Tappan

Plate 2, figures 14-17

Plate 3, figures 1-4

Miliammina 30-31-A NIELSEN, 1950, Unpublished M.Sc. Thesis,
Univ. Alberta, p.64, pl.1, figs.3,4.

Miliammina 69C 10-15B CAMPBELL, 1956, Unpublished M.Sc.
Thesis, Univ. Alberta, p.47, pl.3, fig.13.

Miliammina 69C 10-15A CAMPBELL, 1956, Unpublished M.Sc.
Thesis, Univ. Alberta, p.47, pl.3, figs.14,15.

Psamminopelta bowsheri TAPPAN, 1957, U.S. Natl. Mus. Bull.
215, p.211, pl.67, figs.11-18, 22-24. — TAPPAN, 1962,
U.S. Geol. Surv. Prof. Paper 236-C, p.157, pl.37, figs.
11-22.

Psamminopelta subcircularis TAPPAN, 1957, U.S. Natl. Mus.
Bull.215, p.213, pl.67, figs.8-10. — TAPPAN, 1962, U.S.
Geol. Surv. Prof. Paper 236-C, p.158, pl.37, figs.7-10.

Spirolocammina bowsheri EICHER, 1965, Jour. Paleo., Vol.
39, No.5, p.893, pl.103, fig.6, non. fig.10.

DESCRIPTION: Test medium sized, longer than broad,
compressed; periphery sublenticular; ten tubular chambers
arranged planispirally in half coils which become slender
towards the aperture; sutures distinct, slightly depressed,
becoming fainter towards the center; wall finely arenaceous,
much cement; aperture simple at end of last chamber, incon-
spicuous in most specimens.

DIMENSIONS: Length of specimen 0.48 mm.

Width of specimen 0.35 mm.

Range of length 0.33 (0.40) 0.53 mm.

DISTRIBUTION: This species has previously been reported from the Grandstand, Topagoruk, Tuktu, Torok, and Chandler Formations of northern Alaska (Tappan, 1957); the Mowry and Graneros Shales of the western interior United States (Eicher, 1965); the lower Shaftesbury Formation of Alberta (Nielsen, 1950); and from the Cretaceous of the Cameron Hills in the North West Territories (Campbell, 1956).

REMARKS: A total of 184 specimens have been recovered from throughout the section. In this study the species varies from ovate to lenticular in outline. The number of chambers varies from five to eleven.

Miliammina differs from Psamminopelta because of its quinqueloculine chamber arrangement. Spirolocammina has a slight sigmoidal curve to the long axis and a neck.

Tappan (1957) figures two species but from the variation seen in this study it is believed that both may be included under one species. Eicher (1965) figures a specimen of Spirolocammina without a neck or a sigmoidal development. This suggests it belongs to Psamminopelta rather than Spirolocammina.

FIGURED SPECIMENS: G3+73-16

G2+130-17

G3-8-18

G3-8-36

Family LITUOLIDAE de Blainville, 1825

Subfamily HAPLOPHRAGMOIDINAE Maync, 1952

Genus TROCHAMMINOIDES Cushman, 1910

TROCHAMMINOIDES APRICARIUS Eicher

Plate 3, figures 5-7

Trochamminoides apricarius EICHER, 1965, Jour. Paleo., Vol. 39, No.5, p.894, pl.103, figs.7,12.—EICHER, 1966, Contrib. Cushman Found. Foram. Res., Vol.18, Pt.1, p.22, pl.4, fig.10.—EICHER, 1967, Jour. Paleo., Vol.41, No. 1, p.181, pl.17, fig.14.

DESCRIPTION: Test small, periphery rounded, last three chambers lobate; chambers planispiral, evolute, six and one half visible in the ultimate whorl, two and one half in the penultimate whorl; chambers inflated, last three being much larger than the previous ones; sutures distinct, straight; wall finely arenaceous, much cement; aperture simple at the base of the last chamber.

DIMENSIONS: Diameter of specimen 0.25 mm.

Thickness of specimen 0.10 mm.

Range of diameter 0.17 (0.25) 0.33 mm.

DISTRIBUTION: Trochamminoides apricarius has been reported from the upper part of the Graneros, Carlile and the Belle Fourche Shales of the western interior United States (Eicher, 1965, 1966, 1967). It is found randomly distributed throughout the section in this study.

REMARKS: The chambers in the outer whorl of the smaller specimens increase gradually in size. The umbilical area of

many of the specimens is obscured by cement. Some of the specimens recovered have only five chambers in the outer whorl.

Trochamminoides coronus Loeblich and Tappan has more whorls, more chambers per whorl and chambers which increase gradually in size. Trochammina krumensis Tappan has more chambers per whorl and has a true trochoid spiral. The chambers of Haplophragmoides sp. B. Stelck, Wall and Wetter are not as inflated and are nearly all the same size.

FIGURED SPECIMEN: G4-182-19

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES GILBERTI Eicher

Plate 3, figures 8,9

Haplophragmoides gilberti EICHER, 1965, Jour. Paleo., Vol.

39, No.5, p.894, pl.103, figs.11,13,14. — EICHER, 1967, Jour. Paleo., Vol.41, No.1, p.181, pl.17, fig.2.

DESCRIPTION: Test small, compressed; periphery well rounded; chamber arrangement planispiral, partially evolute, ten chambers visible in ultimate whorl, six chambers in penultimate whorl, increasing very gradually in size; sutures distinct, sigmoidal, thickening slightly towards the center; wall finely arenaceous, much cement gives the surface a smooth appearance; aperture at the base of terminal face.

DIMENSIONS: Diameter of specimen 0.25 mm.

Thickness of specimen 0.08 mm.

Range of diameter 0.18 (0.23) 0.33 mm.

DISTRIBUTION: Eicher (1965,1967) reported this species

from the Trochammina rutherfordi mellariolum zone of the Graneros Shale and from the same zone and lower in the Belle Fourche Shale of the western interior United States.

Except for four specimens in the lower three samples it is only found in samples above the lower sandstone unit.

REMARKS: The holotype of Haplophragmoides topagorukensis can be distinguished by its less inflated chambers and involute form. Haplophragmoides howardense Stelck and Wall is very similar to this form but has more inflated chambers with thickened and depressed sutures. H. gilberti could possibly be an ancestral form of H. howardense. Haplophragmoides fraseri Wickenden is more involute and has slightly curved sutures but otherwise is very similar.

FIGURED SPECIMEN: G2+114-20

HAPLOPHRAGMOIDES GLOBOSA Lozo

Plate 4, figures 1-3

Haplophragmoides globosa LOZO, 1944, Amer. Midland Nat., Vol.31, No.3, p.543, pl.2, fig.8. — FRIZZELL, 1954, Bureau Econ. Geol., Univ. Texas, Report Invest. 22, p.60, pl.1, fig.32 (Synonymy).

DESCRIPTION: Test small; periphery broad, well rounded; chamber arrangement planispiral, involute, eight visible in ultimate whorl; chambers inflated, sharply triangular in shape, increasing gradually in size; sutures distinct, straight, thickened; wall finely arenaceous, thickened, much cement; aperture a broad slit at base of final chamber.

DIMENSIONS: Diameter of specimen 0.35 mm.

Thickness of specimen 0.18 mm.

DISTRIBUTION: Haplophragmoides globosa was originally described from the upper Goodland Formation of the Fredricksburg Group of Texas (Lozo, 1944). It has since been reported from the basal Goodland Formation and the underlying Walnut Clay of Oklahoma (Loeblich and Tappan, 1949); and from the Glen Rose Limestone of the Trinity Group of Texas (Frizzel, 1954). In this study the form appears as a single specimen 34 feet below the top of the upper sandstone unit.

REMARKS: Tappan (1957, 1962) figures some specimens of Haplophragmoides topagorukensis Tappan which are very similar to this form.

FIGURED SPECIMEN: G3-34-21

HAPLOPHRAGMOIDES HENDERSONENSE Stelck and Wall

Plate 3, figures 16, 17

Haplophragmoides hendersonense STELCK and WALL, 1954, Res.

Coun. Alberta Report No. 68, p. 25, pl. 2, fig. 4. — EICHER, 1965, Jour. Paleo., Vol. 39, No. 5, p. 895, pl. 104, figs. 1, 2.

DESCRIPTION: Test small, compressed; periphery rounded; chambers arranged planispirally, partially evolute, with edge of penultimate whorl visible; chambers subtriangular, six in the ultimate whorl, last three of approximately the same size; sutures distinct, slightly thickened, radial; wall finely arenaceous, much cement gives a smooth finish to the surface; aperture at the base of the terminal face, obscured.

DIMENSIONS: Diameter of specimen 0.25 mm.

Thickness of specimen 0.05 mm.

Range of diameter 0.18 (0.23) 0.25 mm.

DISTRIBUTION: Haplophragmoides hendersonense has been reported from the central Kaskapau Formation of Alberta (Stelck and Wall, 1954) and from the pre-mellariolum member of the Graneros Shale of the western interior United States (Eicher, 1965). Six specimens have been found above the top of the upper sandstone unit in this study.

REMARKS: Eicher's (1965) figured form shows more of the penultimate whorl.

FIGURED SPECIMEN: G3+73-22

HAPLOPHRAGMOIDES POSTIS Stelck and Wall

subspecies A

Plate 3, figures 13-15

DESCRIPTION: Test medium sized, compressed; periphery rounded; umbilicus shallow; chamber arrangement planispiral, evolute, chambers distinct, increasing rapidly in size, often infilled with orange pellets, nine chambers visible in ultimate whorl, earlier chambers obscured by cement; sutures distinct, straight but often sigmoidal, thickening slightly towards center; wall very finely arenaceous, much cement gives the exterior a vitreous appearance; aperture at base of terminal face, obscured.

DIMENSIONS: Diameter of specimen 0.33 mm.

Thickness of specimen 0.05 mm.

Range of diameter 0.18 (0.25) 0.33 mm.

DISTRIBUTION: This species is abundant throughout the section:

REMARKS: Haplophragmoides postis Stelck and Wall is not as evolute and has strongly inflated chambers. In the sandstone unit the specimens tend to be slightly larger and more coarsely arenaceous. The number of chambers varies from seven and one half to ten in the ultimate whorl. More than 2000 specimens were recovered.

FIGURED SPECIMEN: G3+73-23

G3+73-24

HAPLOPHRAGMOIDES sp. cf. H. TOPAGORUKENSIS Tappan

Plate 3, figures 10-12

?Haplophragmoides topagorukensis TAPPAN, 1957, U.S. Natl.

Mus. Bull. 215, p.203, pl.65, figs.15-25. — TAPPAN, 1962, U.S. Geol. Surv. Prof. Paper 236-C, p.135, pl.31, figs. 1-15. — EICHER, 1967, Jour. Paleo., Vol.41, No.1, p.181, pl.17, figs.10,13.

DESCRIPTION: Test medium sized, compressed; periphery slightly lobate; chambers involute, increasing gradually in size, eight visible in ultimate whorl; sutures obscure, straight, thickened; wall composed of medium size grains covered by cement; aperture at base of final chamber, obscured.

DIMENSIONS: Diameter of specimen 0.60 mm.

Thickness of specimen 0.10 mm.

Range of diameter 0.30 (0.40) 0.80 mm.

DISTRIBUTION: This species has previously been reported from the Grandstand, Topagoruk, Torok, Fortress Mountain and Chandler Formations of Alaska (Tappan, 1957) and from the Belle Fourche Shale of Wyoming and Montana (Eicher, 1967). It is restricted to samples below the upper sandstone unit in this study.

REMARKS: Most of the 49 specimens are compressed and poorly preserved. The holotype of Haplophragmoides topagorukensis has more chambers in the ultimate whorl and does not have a lobate periphery. Some of the specimens figured by Tappan (1957, 1962) may be comparable to the holotype but others seem to exhibit more variability than one would want to encompass in one morphologic group.

Haplophragmoides collyra Nauss is similar but is partially evolute and has a more lobate periphery.

FIGURED SPECIMEN: G3-28-25

Subfamily LITUOLINAE de Blainville, 1825

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES PACALIS Stelck and Wall

subspecies A

Plate 4, figures 4, 5, 10

DESCRIPTION: Test medium sized, robust, elongate, oval in cross section; coiled portion tightly coiled with the same width as the uniserial portion and comprising one-quarter the overall length of the test; three chambers in the coil; uniserial portion straight, with three chambers,

the last of which is larger and pyriform; sutures distinct, straight, depressed; wall finely arenaceous, much cement; aperture terminal on last chamber of uniserial portion.

DIMENSIONS: Diameter of coil 0.15 mm.

Width of uniserial portion 0.15 mm.

Length of specimen 0.53 mm.

Range of length 0.33 (0.45) 0.78 mm.

Range of coil diameter 0.13 (0.18) 0.28 mm.

DISTRIBUTION: Over 1100 specimens were recovered from throughout the section.

REMARKS: Included with this species are specimens which have two and four chambers in the uniserial portion. Also the coiled portion varies from three to four chambers. In some samples the specimens are composed of medium sized grains. The type with four chambers to the uniserial portion is taken to represent the adult form. The forms with more chambers in the uniserial portion probably reflect more favorable growth conditions. Thus, in a given sample, a low ratio of small to large specimens may give an indication of periods when the environment was more favorable.

Within the assemblage there is a large number of specimens in which it is very difficult to see the coiled portion. As such they bear a strong resemblance to Reophax. They may in fact, however represent the megalospheric form.

A coil which is wider than the uniserial portion, a slightly less pyriform ultimate chamber and slightly more inflated chambers in the coil distinguish Ammobaculites pacalis Stelck and Wall from Ammobaculites pacalis subsp. A.

FIGURED SPECIMEN: G3+60-26
G2+130-28

AMMOBACULITES sp. A

Plate 4, figures 8,9

DESCRIPTION: Test small, short, compressed; coiled portion partially evolute, wider than uniserial portion; five to six chambers in last whorl of coil which obscure inner whorls; one chamber in uniserial portion; sutures distinct, straight; wall finely arenaceous, much cement; aperture simple, terminal at end of uniserial portion.

DIMENSIONS: Diameter of coil 0.23 mm.

Width of uniserial portion 0.15 mm.

Length of specimen 0.28 mm.

Range of length 0.23 (0.28) 0.35 mm.

Range of diameter 0.13 (0.20) 0.25 mm.

DISTRIBUTION: This form was found only in four samples above the top of the upper sandstone unit.

REMARKS: Two specimens assigned to this form have two chambers in the uniserial portion. Thirteen specimens were recovered for study.

FIGURED SPECIMEN: G2+125-29

AMMOBACULITES sp. B

Plate 4, figures 6,7

DESCRIPTION: Test medium sized, elongate; coiled portion tightly coiled, small, one-half the width of ultimate chamber and comprising one-fifth of the overall length of the

test, three chambers in coil; uniserial portion tapered with last chamber much larger than previous three, first three chambers are subquadrate but the last is longer than it is wide; sutures straight, slightly depressed, not very distinct; wall coarsely arenaceous; aperture simple, obscured, terminal on last formed chamber.

DIMENSIONS: Diameter of coil 0.13 mm.

Maximum width of uniserial portion 0.23 mm.

Length of specimen 0.65 mm.

Range of length 0.50(0.63) 0.65 mm.

Range of coil diameter 0.13 (0.15) 0.18 mm.

DISTRIBUTION: Only four specimens of this species were recovered from above the upper sandstone unit.

FIGURED SPECIMEN: G2+114-30

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus TEXTULARIA Defrance, 1824

TEXTULARIA GRAVENORI Stelck and Wall

Plate 4, figures 15,16

Textularia gravenori STELCK and WALL, 1955, Res. Coun.

Alberta Report, No.70, p.55, pl.2, fig.36.—TAPPAN, 1962, U.S. Geol. Surv. Prof. Paper 236-C, p.141, pl.33, figs.16,17.—HUFFMAN, 1969, Unpublished M.Sc. Thesis, Univ. Sask., p.34, pl.2, fig.1.—GIVEN, 1969, Unpublished M.Sc. Thesis, Univ. Alberta, p.80, pl.1, figs. 32,33.

DESCRIPTION: Test minute, compressed, slightly tapered; early chambers very small, obscured by cement, thought to be four in number; later chambers biserially arranged, ten in number, inflated; sutures slightly depressed, wall finely arenaceous; aperture not observed.

DIMENSIONS: Length of specimen 0.25 mm.

Width of specimen 0.10 mm.

Range of length 0.25 (0.30) 0.38 mm.

DISTRIBUTION: Textularia gravenori was originally described from the lower portion of the central part of the Kaskapau Formation of Alberta. In addition it has been reported from the Seabee Formation of Alaska (Tappan, 1962) and from the base of the Lea Park Shale of Saskatchewan (Huffman, 1969). In this study six specimens were found from four randomly distributed samples.

REMARKS: The specimens found have fewer chambers than the holotype. This could be caused by an unfavorable environment for growth.

FIGURED SPECIMEN: G3-28-31

TEXTULARIA RIOENSIS Carsey

Plate 4, figures 11, 12

Textularia rioensis CARSEY, 1926, Univ. Texas Bull. 2612,

p. 24, pl. 7, fig. 2. — EICHER, 1965, Jour. Paleo., Vol. 39, No. 5, p. 897, pl. 104, fig. 6 (synonymy).

Spiroplectammina acostai Tappan. EICHER, 1966, Contrib.

Cushman Found. Foram. Res., p. 23, pl. 4, fig. 17, non. fig. 20.

DESCRIPTION: Test small, compressed; chamber arrangement biserial; chambers flaring rapidly from a rounded base, early chambers wider than high, sloping toward periphery; later chambers becoming inflated, first two chambers very small and obscured, next eight chambers increase quickly in size; sutures obscure; wall finely arenaceous; aperture obscured, indistinct, thought to be at inner base of final chamber.

DIMENSIONS: Length of specimen 0.30 mm.

Width of specimen 0.20 mm.

Range of length 0.25 (0.33) 0.43 mm.

DISTRIBUTION: Textularia rioensis has previously been reported from the Washita Group (Tappan, 1940, 1943), the Fredericksburg and Trinity Groups, (Lozo, 1944) and the Woodbine Group of Texas (Frizzell, 1954). In the western interior United States Eicher (1965, 1966) has reported it from the Trochammina rutherfordi mellariolum zone of the Graneros and Carlile Shales. It was found in all but five samples from the lower Neogastroplites zone.

REMARKS: Tappan (1962) felt that Textularia topagorukensis Tappan is the megalospheric stage of Spiroplectammina koveri Tappan. Eicher (1966) figured a specimen of Spiroplectammina acostai which does not begin with a coil. A few of the specimens in this study have a suggestion of an early coil. Thus it is thought there may be a relationship between Textularia rioensis and Spiroplectammina acostai but a much larger population should be examined before this can be confirmed.

The chambers flare rapidly to moderately rapidly. On a given specimen the number of chambers may vary from eight to ten. About 140 specimens were recovered for study.

FIGURED SPECIMEN: G3+73-32

TEXTULARIA sp.

Plate 4, figures 13,14

DESCRIPTION: Test minute, slightly tapering; six chambers in biserial arrangement; chambers inflated, increasing gradually in size; sutures distinct, slightly depressed; wall finely arenaceous, much cement gives the surface a smooth finish; aperture simple, at base of inner face of last chamber.

DIMENSIONS: Length of specimen 0.23 mm.

Width of specimen 0.10 mm.

DISTRIBUTION: A single specimen was found in sample G3-21.

FIGURED SPECIMEN: G3-21-33

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA RUTHERFORDI MELLARIOLUM Eicher

Plate 4, figures 17-19

Trochammina rutherfordi Stelck and Wall subspecies mellar-
iolum EICHER, 1965, Jour. Paleo., Vol.39, No.5, p.899,

pl.105, figs.4,9.—EICHER, 1967, Jour. Paleo., Vol.41, No.1, p.184, pl.18, fig.12.

DESCRIPTION: Test small, ventrally umbilicate, dorsally spired, consisting of four whorls; chambers decrease from six in first whorl to three and one-half in ultimate whorl; chambers inflated, increasing gradually in size until last whorl where they increase rapidly; sutures distinct, slightly thickened, slightly depressed; wall finely arenaceous, much cement obscures the earlier whorls; aperture a thin slit along ventral margin, obscured.

DIMENSIONS: Diameter of specimen 0.20 mm.

Height of specimen 0.30 mm.

Range of diameter 0.15 (0.18) 0.28 mm.

Range of height 0.18 (0.23) 0.33 mm.

DISTRIBUTION: Trochammina rutherfordi mellarium has been reported from a thin zone in the Graneros and Belle Fourche Shales of the Western interior United States (Eicher, 1965, 1966). In this study, except for one specimen, it occurs from 135 feet above the top of the upper sandstone unit to 68 feet below it.

REMARKS: Some specimens are composed of medium sized grains which produces a rough surface texture.

The specimens range from moderately high spired to extremely high spired. If found alone the extremely high spired forms would be difficult to distinguish from Eggerella. A total of 132 specimens were recovered.

FIGURED SPECIMEN: G2+130-34

TROCHAMMINA UMIATENSIS Tappan

Plate 5, figures 1-4

Trochammina umiatensis TAPPAN, 1957, U.S. Natl. Mus. Bull.

215, p.214, pl.67, figs.27-29.— TAPPAN, 1962, U.S.

Geol. Surv. Prof. Paper 236-C, p.156, pl.38, figs.5-8.

Trochammina hisanohamaensis Asano. TAKAYANAGI, 1960, Science

Reports Tohoku Univ., Vol.32, No.1, p.86, pl.4, fig.2.

DESCRIPTION: Test, medium sized, trochoid, compressed; umbilicus shallow, obscured; test low spired, consisting of three whorls, three and one-half chambers in each whorl, chambers inflated, gradually increasing in size; sutures distinct, depressed, straight on ventral side, curved on the dorsal; wall finely arenaceous, much cement; aperture not visible, believed to be a low slit on ventral face of last chamber.

DIMENSIONS: Diameter of specimen 0.38 mm.

Height of specimen 0.10 mm.

Range of diameter 0.23 (0.30) 0.38 mm.

DISTRIBUTION: Previously T. umiatensis has been reported from the Grandstand and Topagoruk Formations of Alaska (Tappan, 1957, 1962) and from the uppermost part of the Shell Creek Shale of Wyoming (Eicher, 1960). Takayanagi (1960) reported a similar form from the Lower Miyakoan to the Lower Hetonaian (Aptian to Lower Campanian) of Japan. Except for one sample it is found throughout the lower Neogastrolites zone with over 760 specimens being recovered.

REMARKS: The specimen described is believed to represent

the microspheric stage. The megalospheric stage is represented by a much more inflated form which only has two whorls but otherwise agrees with the description of the microspheric stage. As most of the specimens are crushed and poorly preserved it is difficult to distinguish the two forms except in a few excellently preserved specimens.

All the specimens recovered have three and one-half to four chambers in the ultimate whorl and match Tappan's (1957) figured holotype. Eicher (1960, pl.6, fig.5) figured a specimen which he called T. umiatensis but later (Eicher, 1967) considered it identical with Trochammina wetteri Stelck and Wall. Eicher (1967, pl.18, fig.7) figured a flattened specimen of T. wetteri which showed five chambers in the ultimate whorl. The writer believes this flattened form probably is T. wetteri, but that T. umiatensis should be retained for the lower spired form with three and one-half to four chambers per whorl, as figured by Tappan (1957) and Eicher (1960). The chambers of the forms assigned here are much larger and more globose than the chambers of the form assigned to T. wetteri.

FIGURED SPECIMENS: G2+130-35

G4-187-37

TROCHAMMINA WETTERI Stelck and Wall

Plate 5, figures 5,6

Trochammina wetteri (nomen nudum), 1954, Res. Counc. Alberta, Report No.68, pp.10,11,13.

Trochammina wetteri STELCK and WALL, 1955, Res. Coun.

Alberta Report No.70, p.59, pl.2, figs.1-3, 6. — WALL, 1967a, Res. Coun. Alberta, Bull.20, p.71, pl.8, figs.21-26, pl.10, figs.7-9 (synonymy).

DESCRIPTION: Test small, trochoid, umbilicus shallow, obscured; test low spired, consisting of two and one-half whorls, five chambers in ultimate whorl, six chambers in the penultimate whorl; chambers inflated, globular, much larger in ultimate whorl; sutures distinct, depressed, radial on umbilical side, curved on spiral side, wall finely arenaceous; aperture a thin slit on ventral margin of last chamber, obscured.

DIMENSIONS: Diameter of specimen 0.23 mm.

Height of specimen 0.15 mm.

Range of diameter 0.18 (0.25) 0.38 mm.

DISTRIBUTION: Originally it was reported from the lower Kaskapau Formation of British Columbia and Alberta. Eicher (1967) reported it from the Belle Fourche Shale of the western interior United States while Bergquist (1966) reported it from the type section of the Ninuluk Formation of northern Alaska.

REMARKS: Trochammina wickendeni Loeblich is distinguished from this form by its lower spire and fewer whorls. Trochammina albertensis Wickenden has a much higher spire. The holotype of Trochammina umiatensis Tappan differs from this in having only three and one-half chambers in the ultimate whorl. Only 13 specimens were recovered for study.

FIGURED SPECIMEN: G2+130-38

TROCHAMMINA WICKENDENI Loeblich

Plate 5, figures 7-10

Trochammina wickendeni LOEBLICH, 1946, Jour. Paleo., Vol.20, No.2, p.138, pl.22, fig.17. — FRIZZELL, 1954, Bureau of Econ. Geol., Univ. Texas, Report Invest. 22, p.79, pl.7, fig.24. — EICHER, 1966, Contrib. Cushman Found. Foram. Res., Vol.17, Pt.1, p.24, pl.4, fig.22.

Trochammina 11-39-A STELCK, 1950, Unpublished Ph.D. Thesis, Stanford Univ., p.172, pl.6, figs.27,28.

Trochammina sp. 1, FOX, 1954, U.S. Geol. Surv. Paper 254-E, p.112, pl.24, figs.11-13.

DESCRIPTION: Test small, trochoid, periphery round, lobate, deeply umbilicate; test very low spired, consisting of two whorls, five chambers in ultimate whorl; chambers inflated, globose, increasing in size rapidly to ultimate whorl in which chambers are approximately the same size; sutures distinct, depressed, straight; wall very finely arenaceous, much cement gives the specimen a hyaline appearance; aperture a thin slit along the ventral margin of the last chamber.

DIMENSIONS: Diameter of specimen 0.33 mm.

Height of specimen 0.13 mm.

Range of diameter 0.20 (0.25) 0.35 mm.

DISTRIBUTION: Trochammina wickendeni was originally described from the Pepper Shale of Texas. It has since been

reported from above the Fourth Sikanni sandstone of British Columbia (Stelck, 1950); from the upper part of the Belle Fourche Shale of Wyoming (Fox, 1954) and from the Carlile Shale of Colorado (Eicher, 1966).

REMARKS: Most of the specimens are poorly preserved with some having only four chambers in the ultimate whorl.

Twenty-one specimens were recovered for study.

Trochammina sp. 3 (Fox, 1954) is distinguished from this form by its slightly larger size and its more coarsely arenaceous wall. Trochammina albertensis Wickenden has a higher spire, slightly inflated chambers and curved sutures.

FIGURED SPECIMEN: G3-78-39

Family ATAXOPHRAGMIIDAE Schwager, 1877

Subfamily VERNEUILININAE Cushman, 1911

Genus VERNEUILINA d'Orbigny, 1839

VERNEUILINA ALAMEDA Eicher

Plate 5, figures 15, 16

Verneulina 3-165-A STELCK, 1950, Unpublished Ph.D. Thesis,

Stanford Univ., p.181, pl.7, figs.5,6.

Verneuilina alameda EICHER, 1965, Jour. Paleo., Vol.39,

No.5, p.900, pl.104, fig.10,11. — EICHER, 1967, Jour.

Paleo., Vol.41, No.1, p.185.

DESCRIPTION: Test small, tapering, triangular in cross section with narrowly rounded edges and flat sides; chamber arrangement triserial with six convolutions; chambers inflated, gradually increasing in size; sutures slightly depressed, sloping slightly towards edge; wall finely aren-

aceous, much cement gives the surface a smooth finish; aperture obscured, thought to be a small notch at the base of the last chamber.

DIMENSIONS: Length of specimen 0.30 mm.

Maximum width of specimen 0.18 mm.

Range of length 0.23 (0.33) 0.58 mm.

DISTRIBUTION: It has been reported from the lower portion of the Graneros Shale and as a single specimen in the lower part of the Belle Fourche Shale of the western interior United States (Eicher, 1965, 1967). Stelck (1950) reported it from the lower Kaskapau Shale of Alberta. In this study it occurs in two fifteen to twenty-foot zones. One is just above the lower sandstone unit and the other is just above the base of the section.

REMARKS: V. alameda is distinguished from Verneuilioides perplexus (Loeblich) by its straight sides, triangular cross section and lack of twisting in the long axis. Verneuilina canadensis Cushman is larger, has concave sides, overhanging chambers and steeply sloping sutures. Verneuilina porta Stelck and Wall is larger and has a black coating.

FIGURED SPECIMEN: G3-24-40

Genus VERNEUILINOIDES Loeblich and Tappan, 1949

VERNEUILINOIDES PERPLEXUS (Loeblich)

Plate 5, figure 18

Verneuilina perplexa LOEBLICH, 1946, Jour. Paleo., Vol. 20, No. 2, p. 138, pl. 22, figs. 14-16.

Verneuulinoides perplexa (Loeblich). LOEBLICH and TAPPAN, 1949a, Jour. Wash. Acad. Sciences, p.91.

Verneuilina? 31-258-A NIELSEN, 1950, Unpublished M.Sc. Thesis, Univ. Alberta, p.83, pl.1, fig.6.

Verneuulinoides kansasensis LOEBLICH and TAPPAN, 1950, Univ. Kansas Paleont. Contrib., Protozoa, Art.3, p.10, pl.2, fig.2, non. fig.1. — EICHER, 1960, Peabody Mus. Nat. History, Yale Univ., Bull.15, p.69, pl.5, fig.6, non. figs.7-10. — CRESPIN, 1963, Aust. Bureau Min. Resources, Geol. and Geophy. Bull., No.66, p.57, pl.15, figs.4-7. — WALL, 1967a, Res. Coun. Alberta, Bull.20, p.76, pl.2, figs.1-7.

Verneuulinoides perplexus (Loeblich). FRIZZELL, 1954, Bureau Econ. Geol., Univ. Texas Report 22, p.69, pl.5, fig.10. — STELCK and WALL, 1955, Res. Coun. Alberta, Report No.70, p.60, pl.2, fig.37, pl.3, figs.29,30.

Verneuulinoides perplexus gleddiei STELCK and WALL, 1955, Res. Coun. Alberta, Report No.70, p.61, pl.2, figs.40,41.

Verneuilina 60c 165-174A CAMPBELL, 1956, Unpublished M.Sc. Thesis, Univ. Alberta, p.57, pl.2, fig.20.

DESCRIPTION: Test small, subtriangular in cross section; chamber arrangement triserial with the chambers slightly twisted about the long axis, five convolutions; chambers inflated, gradually increasing in size; sutures distinct, depressed; wall finely arenaceous, much cement gives the surface a smooth finish; aperture obscured, believed to be at the base of the inner margin of the ultimate chamber.

DIMENSIONS: Length of specimen 0.30 mm.

Maximum width of specimen 0.18 mm.

Range of length 0.20 (0.28) 0.38 mm.

DISTRIBUTION: V. perplexus was originally reported from the type section of the Pepper Shale of Texas. It has since been reported from the type section of the Kiowa Shale of Kansas (Loeblich and Tappan, 1950); from the Thermopolis, Skull Creek, Graneros, and Belle Fourche Shales of the western interior United States (Eicher, 1960, 1965, 1967); from below the Fish Scale Marker in the Shaftesbury Formation of Alberta (Nielsen, 1950); from the basal Kaskapau Formation of Alberta (Stelck and Wall, 1955); from the Cretaceous of the Cameron Hills, N.W.T. (Campbell, 1956) and from the Lower Cretaceous of Australia (Crespin, 1963).

REMARKS: This species is very susceptible to crushing and slight elongation of the long axis. In the assemblage found here there is considerable variation between individual specimens. However, when the assemblage as a whole is viewed it can be seen that compression can cause these extremes.

Both Verneuiliinoides schizeus (Cushman and Alexander) and Verneuiliinoides hectori (Nauss) are larger and more elongate than V. perplexus. Over 770 specimens have been studied but none show the extreme elongation which Eicher (1960, 1965, 1966) shows in some figures and as such they have not been considered to be identical.

FIGURED SPECIMEN: G2+125-41

VERNEUILINOIDES sp.

Plate 5, figure 17

DESCRIPTION: Test small, elongate, subtriangular in cross section; chamber arrangement triserial, twisted about the long axis, seven convolutions; chambers slightly inflated and about the same size in first three convolutions, last four convolutions inflated and increasing quickly in size; sutures obscured in earlier portion becoming distinct and depressed in later portion; wall finely arenaceous, much cement; aperture not visible, thought to be at base of inner face of last chamber.

DIMENSIONS: Length of specimen 0.34 mm.

Width of specimen 0.18 mm.

Range of length 0.23 (0.30) 0.40 mm.

DISTRIBUTION: This species is found in all but three samples in the lower Neogastroplites zone.

REMARKS: Verneuilioides sp. can be distinguished from Verneuilioides perplexus by its more elongate form and additional chambers. It is difficult to distinguish from Gaudryina? sp. because of the poor preservation but generally Gaudryina? sp. is much longer. The number of convolutions ranges from five to seven. A total of 370 specimens was recovered.

FIGURED SPECIMEN: G3-28-42

Genus TRITAXIA Reuss, 1860

"TRITAXIA" sp. cf. T. MANITOBENSIS Wickenden

Plate 5, figures 11-13

?Tritaxia manitobensis WICKENDEN, 1932a, Trans. Royal Soc.

Can., Series 3, Vol.26, Sect.4, p.87, pl.1, fig.10. —

NIELSEN, 1950, Unpublished M.Sc. Thesis, Univ. Alberta,
p.76, pl.1, figs.11,12.?Uvigerinamina manitobensis (Wickenden). TAPPAN, 1962, U.S.

Geol. Surv. Prof. Paper 236-C, p.145, pl.33, figs.18-23.

"Tritaxia" manitobensis Wickenden. BERGQUIST, 1966, U.S.

Geol. Surv. Prof. Paper 302-D, p.137, fig.39.

DESCRIPTION: Test medium sized, elongate, twisted;
chamber arrangement biserial throughout; chambers inflated,
overlapping; sutures distinct, curved, thickened; wall
finely arenaceous, much cement; aperture a thin slit on
extended portion of last chamber.

DIMENSIONS: Length of specimen 0.40 mm.

Width of specimen 0.23 mm.

Range of length 0.30 (0.38) 0.50 mm.

DISTRIBUTION: T. manitobensis was originally reported
from the lower Ashville beds of Manitoba. It has since
been reported from below the fish scale zone in the lower
part of the Shaftesbury Formation of Alberta (Nielsen, 1950);
from the Cretaceous of the Cameron Hills, N.W.T. (Campbell,
1956); from the Tuktu, Topagoruk and Grandstand Formations
of Alaska (Tappan, 1951, 1962) and from the Kukpowruk Form-
ation of Alaska (Bergquist, 1966). In this study it occurs
irregularly in the section.

REMARKS: The characteristics of "Tritaxia" and the difference between it and Uvigerinammina are brought out in an excellent discussion by Bergquist (1966, pp.137-139). He found from studies of plasticine models of Uvigerinammina that it did not assume a biserial form when compressed. Siphotextularia Finlay is similar but has a quadrate outline and a tube-like aperture on the inside face of the last chamber rather than a terminal aperture. The form studied here appears to conform to the definition of the genus Pseudobolivina Wiesner and should probably be assigned to it. Wickenden's (1932a) figure of the holotype of Tritaxia manitobensis appears to be biserial but as the writer has not examined it, this group has not been assigned to the genus Pseudobolivina.

Many of the specimens have been twisted which gives a false impression that they may be triserial. The late chambers in other specimens appear to be uniserial but again this is due to being altered. This species is particularly fragile and most of the specimens have part of the last chamber or the early chambers broken off.

FIGURED SPECIMEN: G2+130-43

G3+73-44

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA? sp.

Plate 5, figure 14

DESCRIPTION: Test medium sized, elongate, ovate in

cross section, early portion triserial, later portion biserial and about the same length; chambers inflated, twelve in broken triserial portion, eight in biserial portion; sutures distinct, depressed; wall finely arenaceous, much cement gives the surface a smooth finish; aperture a broad low slit at inner face of last chamber.

DIMENSIONS: Length of specimen 0.45 mm.

Width of specimen 0.13 mm.

Length of biserial portion 0.25 mm.

Range in length 0.30 (0.40) 0.53 mm.

DISTRIBUTION: Gaudryina? sp. is not found above the top of the upper sandstone unit and only randomly below it.

REMARKS: The figured specimen has the early chambers removed. Other specimens studied appear to have 15 chambers in the triserial portion, however they are all flattened and are very finely arenaceous. The chambers are very obscure making it very difficult to distinguish this species from Verneuulinoides sp.

FIGURED SPECIMEN: G4-197-45

Subclass RADIOLARIA Muller, 1858

Genus DICTYOMITRA Zittel, 1876

DICTYOMITRA? sp.

Plate 5, figures 19,20

DESCRIPTION: Shell conical shaped, circular in cross section; distinct transverse furrows, about ten in number; has very finely arenaceous appearance, grey in color.

DIMENSIONS: Length of specimen 0.23 mm.

Maximum width of specimen 0.10 mm.

DISTRIBUTION: Only one specimen was found 21 feet below the top of the upper sandstone unit.

FIGURED SPECIMEN: G3-21-46

INCERTAE SEDIS

Fecal Pellets?

Plate 5, figure 21

DESCRIPTION: Elliptical in shape, smooth surface, light brown in color.

DIMENSIONS: Length of specimen 0.20 mm.

Width of specimen 0.18 mm.

Range of length 0.20 (0.23) 0.28 mm.

DISTRIBUTION: Seven specimens were found from four samples randomly distributed below the upper sandstone unit.

FIGURED SPECIMEN: G3-21-47

REFERENCES CITED

- Alberta Study Group, 1954, Lower Cretaceous of Peace River region, in Symposium Western Canada Sedimentary Basin; Amer. Assoc. Pet. Geol., pp.1-521.
- Atlee, W.A., 1962, The Lower Cretaceous Paluxy Sand in Central Texas; Baylor Geological Studies, Bull. No.2, pp.1-25.
- Bahan, W.G., 1951, Microfauna of the Joli Fou Formation in North Central Alberta, Unpublished M.Sc. Thesis; Univ. Alberta, pp.1-43, pl.1.
- Bandy, O.L. and Arnal, R.E., 1960, Concepts of Foraminiferal Paleocology; Bull. Amer. Assoc. Pet. Geol., Vol.44, No.12, pp.1921-1932.
- Bandy, O.L. et. al., 1967, Paleocology; Amer. Geol. Institute Short Course Lecture Notes.
- Bergquist, H.R., 1966, Micropaleontology of the Mesozoic Rocks of Northern Alaska; U.S. Geol. Surv. Prof. Paper 302-D, pp.93-227.
- Campbell, D.L., 1956, Cretaceous Microfauna from Cameron Hills, N.W.T.; Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-64, pls.1-3.
- Carsey, D.O., 1926, Foraminifera of the Cretaceous of Central Texas; Univ. Texas Bull. 2612, pp.1-56, pls.1-8.
- Church, C.C., 1968, Lower Cretaceous Foraminifera of the Orchard Peak-Devils Den Area California; Proceedings Calif. Acad. Sc., Vol.32, No.18, pp.523-580, pls.1-8.
- Cobban, W.A. and Reeside, J.B., 1952, Correlation of the Cretaceous Formations of the Western Interior of the United States; Bull. Geol. Soc. Amer., Vol.63, pp.1011-1044.
- Crespin, I., 1963, Lower Cretaceous Arenaceous Foraminifera of Australia; Aust. Bureau Min. Resources, Geol. and Geophy. Bull. No.66, pp.1-110, pls.1-18.
- Cushman, J.A., 1927, Some Foraminifera from the Cretaceous of Canada; Proc. Royal Soc. Can., Vol.21, pp.127-134, pl.1.

- Cushman, J.A., 1946, Upper Cretaceous Foraminifera of the Gulf Coastal region of the United States and adjacent areas; U.S. Geol. Surv. Prof. Paper 206, pp.1-241, pls.1-45.
- _____ 1959, Foraminifera their classification and economic use; Harvard Univ. Press, pp.1-605, pls.1-55.
- Cushman, J.A. and Applin, E.R., 1946, Some Foraminifera of Woodbine age from Texas, Mississippi, Alabama and Georgia; Contrib. Cushman Lab. Foram. Res., Vol.22, Pt.3, pp.71-76, pl.13.
- _____ 1947, Some new Foraminifera from the American Cretaceous; Contrib. Cushman Lab. Foram. Res., Vol. 23, Pt.3, pp.53-55, pl.13.
- Davis, J.C., 1970, Petrology of Cretaceous Mowry Shale of Wyoming; Bull. Amer. Assoc. Pet. Geol., Vol.54, No.3, pp.487-502.
- Dawson, G.M., 1881, Report on an exploration from Port Simpson on the Pacific Coast to Edmonton on the Saskatchewan, embracing a portion of the northern part of British Columbia and Peace River Country; Geol. Nat. Hist. Surv. Can., Rept Prog. 1879-80, Pt.B, pp.1-177.
- Eicher, D.L., 1960, Stratigraphy and Micropaleontology of the Thermopolis Shale; Peabody Mus. Nat. History, Yale Univ., Bull. 15, pp.1-126, pls.1-6.
- _____ 1965, Foraminifera and Biostratigraphy of the Graneros Shale; Jour. Paleo., Vol.39, pp.875-909, pls.103-106.
- _____ 1966, Foraminifera from the Cretaceous Carlile Shale of Colorado; Contrib. Cushman Found. Foram. Res. Vol.17, Pt.1, pp.16-31, pls.4,5.
- _____ 1967, Foraminifera from Belle Fourche Shale and equivalents, Wyoming and Montana; Jour. Paleo. Vol.41, No.1, pp.167-188, pls.17-19.
- Folinsbee, R.E., Baadsgaard, H. and Cumming, G.L., 1963, Dating of Volcanic Ash Beds (Bentonites) by the K-Ar Method; Nat. Acad. Sciences - Nat. Res. Coun. Nuclear Science Series, Rept.38, Publication 1075, pp.70-82.
- Fox, S.K. Jr., 1954, Cretaceous Foraminifera from the Greenhorn Carlile and Cody Formations South Dakota, Wyoming; U.S. Geol. Surv. Prof. Paper 254-E, pp.97-124, pls.24-26.

- Frizzell, D.L., 1954, Handbook of Cretaceous Foraminifera of Texas; Bureau Econ. Geol., Univ. Texas, Report of Investigations No.22, pp.1-232, pls.1-21.
- Given, M.M., 1969, Foraminifera of the Bearpaw Formation, Central Southeastern Alberta; Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-157, pls.1-3.
- Gleddie, J., 1954, Upper Cretaceous in Western Peace River Plains, Alberta, in Symposium Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., pp.1-521.
- Greiner, H.R., 1955, Two Lakes, Alberta; Geol. Surv. Can. Paper 55-14, pp.1-9.
- Guliov, P., 1966, Two new Middle Albian species of Foraminifera from Saskatchewan; Contrib. Cushman Found. Foram. Res. Vol.17, Pt.4, pp.142-143, 1 pl.12.
- _____, 1967, Lower Cretaceous (Middle Albian) Foraminifera from Saskatchewan; Sask. Dept. Min. Resources Report No.105, Pt.1, pp.1-40, pls.1-7.
- Hage, C.O., 1944, Geology adjacent to the Alaska Highway between Fort St. John and Fort Nelson, British Columbia; Geol. Surv. Can. Paper 44-30, pp.1-22.
- Hattin, D.E., 1965, Stratigraphy of the Graneros Shale (Upper Cretaceous) in Central Kansas; Kansas State Geol. Surv. Bull.178, pp.1-83, pls.1-5.
- Henderson, W.R.S., 1954, Cretaceous and Some Triassic beds of Northeastern British Columbia, Canada, Bull. Amer. Assoc. Pet. Geol., Vol.38, No.11, pp.2269-2289.
- Huffman, D.P., 1969, Biostratigraphy of the Upper Cretaceous White-Speckled Shales in Western Saskatchewan; Unpublished M.Sc. Thesis, Univ. Saskatchewan, pp.1-102, pls.1-3.
- Jeletzky, J.A., 1968, Macrofossil zones of the Marine Cretaceous of the Western Interior of Canada and their Correlation with the zones and stages of Europe and the Western Interior of the United States; Geol. Surv. Can. Paper 67-72, pp.1-66.
- Irish, E.J.W., 1955, Adam's Lookout (West half), Alberta; Geol. Surv. Can. Paper 54-19,
- Khan, M.H., 1952, Zonal Analysis of the Lower Gault of Kent based on Foraminifera; Contrib. Cushman Found. Foram. Res. Vol.3, Pt.2, pp.71-80.

- Kindle, E.D., 1944, Geological reconnaissance along Fort Nelson, Liard and Beaver Rivers, Northeastern British Columbia and Southeastern Yukon; Geol. Surv. Can. Paper 44-16, pp.1-19.
- Lamb, G.M., 1969, Two New Species of Foraminifera from the Lower Mancos Shale (Upper Cretaceous) of the San Juan Basin, New Mexico; Contrib. Cushman Found. Foram. Res. Vol.20, Pt.4, pp.143-144.
- Loeblich, A.R. Jr., 1946, Foraminifera from the type Pepper Shale of Texas; Jour. Paleo., Vol.20, No.2, pp.130-139, pl.22.
- Loeblich, A.R. and Tappan, H., 1946, New Washita Foraminifera; Jour. Paleo., Vol.20, No.3, pp.238-258, pls.35-37.
- _____, 1949a, New Kansas Lower Cretaceous Foraminifera; Jour. Wash. Acad. Sciences, Vol.30, No.3, pp.90-92.
- _____, 1949b, Foraminifera from the Walnut Formation (Lower Cretaceous) of Northern Texas and Southern Oklahoma; Jour. Paleo., Vol.23, No.3, pp.245-266, pls.46-51.
- _____, 1950, Foraminifera from the type Kiowa Shale, Lower Cretaceous, of Kansas, Univ. Kansas Paleont. Contrib., Protozoa, Art.3, pp.1-15, pls.1,2.
- _____, 1953, Studies of Arctic Foraminifera, Smithsonian Misc. Collections, Vol.121, No.7, pp.1-150, pls.1-24.
- _____, 1961a, The Status of the Foraminiferal Genera Ammodiscus Reuss, and Involutina Terquem, Micropaleo., Vol.7, No.2, pp.189-192.
- _____, 1961b, The Type Species of the Foraminifera Genus Saccammina Carpenter, 1869; Contrib. Cushman Found. Foram. Res. Vol.12, Pt.3, pp.79-80.
- _____, 1964, Treatise on Invertebrate Paleontology, Pt.C, Protista 2, Geol. Soc. Amer. and Univ. Kansas Press, pp.1-900.
- Lozo, F.E. Jr., 1944, Biostratigraphic Relations of some North Texas Trinity and Fredericksburg (Comanchean) Foraminifera; Amer. Midland Nat. Vol.31, No.3, pp.513-582, pls.1-5.
- McConnell, R.F., 1893, On a portion of the District of Athabaska comprising the country between Peace River and Athabaska River; Geol. Surv. Can. Ann. Report 1890-91, Vol.5, Pt.D, pp.1-67.

- McLearn, F.H., 1918, Peace River section, Alberta, Geol. Surv. Can. Summary Report 1917, Pt.C, pp.14-21.
- _____, 1931, The Gastropylites and other Lower Cretaceous faunas of the Northern Great Plains; Trans. Royal Soc. Can., Sect. 4, Series 3, Vol.25, pp.1-8.
- _____, 1932, Problems of the Lower Cretaceous of the Canadian Interior; Trans. Royal Soc. Can., Sect.4, Series 3, Vol.26, pp.157-175.
- _____, 1933, The Ammonoid Genera Gastropylites and Neogastropylites; Royal Soc. Can. Trans., Series 3, Sect.4, Vol.27, pp.13-24, pls.1-4.
- _____, 1944, Revision of the Palaeogeography of the Lower Cretaceous of the Western Interior of Canada; Geol. Surv. Can. Paper 44-32, pp.1-11.
- _____, 1945, Revision of the Lower Cretaceous of the Western Interior of Canada; Geol. Surv. Can. Paper 44-17, pp.1-14.
- McLearn, F.H. and Henderson, J.F., 1944, Geology and Oil Prospects of Lone Mountain Area, British Columbia; Geol. Surv. Can. Paper 44-2, pp.1-8.
- McLearn, F.H. and Kindle, E.D., 1950, Geology of Northeastern British Columbia; Geol. Surv. Can. Mem.259, pp.1-236.
- Mellon, G.B. and Wall, J.H., 1956, Foraminifera of the Upper McMurray and Basal Clearwater Formations; Res. Coun. Alberta Report No. 72, Pt.1, pp.5-29, pls.1,2.
- _____, 1963, Correlation of the Blairmore Group and Equivalent Strata; Bull. Can. Pet. Geol., Vol.11, No.4, pp.396-409.
- Mellon, G.B., Wall, J.H. and Stelck, C.R., 1963, Lower Cretaceous Section, Belcourt ridge, Northeastern British Columbia; Bull. Can. Pet. Geol., Vol.11, No.1, pp.64-72.
- Moore, R.C. (Editor), 1954, Treatise on Invertebrate Paleontology, Part D, Protista 3, Geol. Soc. Amer. and Univ. Kansas Press, pp.1-195.

- Nauss, A.W., 1947, Cretaceous Microfossils of the Vermilion area, Alberta; Jour. Paleo. Vol.21, No.4, pp.329-343, pls.48,49.
- Nielsen, A.R., 1950, A Microfaunal Study of the Shaftesbury Formation; Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-89, pls.1-2.
- Park, J.M., 1965, Biostratigraphy of the Upper Cretaceous White Speckled Shales in Central Saskatchewan; Unpublished M.A. Thesis, Univ. Saskatchewan, pp.1-78, pls.1-3.
- Patterson, T.E., 1970, Paleomicroflora of the Lower part of the Ashville Formation of Saskatchewan; Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-226, pls.1-9.
- Phleger, F.B. and Parker, F.L., 1951, Ecology of Foraminifera, Northwest Gulf of Mexico, Geological Society of America Memoir 46, pp.1-64, pls.1-19.
- Price, L.L., 1963, Lower Cretaceous Rocks of Southeastern Saskatchewan, Geol. Survey Can. Paper 62-29, pp.1-55.
- Reeside, J.B., 1957, Paleoecology of the Cretaceous Seas of the Western Interior of the United States, in Treatise on Marine Ecology and Paleoecology Vol.2, Geol. Soc. Amer. Mem.67, pp.505-542.
- Reeside, J.B. and Cobban, W.A., 1960, Studies of the Mowry Shale (Cretaceous) and Contemporary Formations in the United States and Canada; U.S.G.S. Prof. Paper 355, pp.1-126, pls.1-58.
- Rudkin, R.A., 1964, Lower Cretaceous in Geological History of Western Canada, Alberta Society of Petroleum Geologists, pp.1-232.
- Scott, R.W., 1967, Paleoecology of the Lower Cretaceous Kiowa, in Paleoenvironments of the Cretaceous Seaway in the Western Interior, A Symposium, Colorado School of Mines, pp.39-65.
- Selwyn, A.R.C., 1877, Report on Exploration in British Columbia in 1875; Geol. Surv. Can., Rept. Prog. 1875-76, pp.28-86.
- Skolnick, H., 1958, Lower Cretaceous Foraminifera of the Black Hills Area, Jour. Paleo. Vol.32, No.2, pp.275-285, pls.36-38.

- Slama, D.C., 1954, Arenaceous Tests in Foraminifera - An Experiment, *The Micropaleontologist*, Vol.8, No.1, pp.33,34.
- Sliter, W.V., 1968, Upper Cretaceous Foraminifera from Southern California and Northwestern Baja California, Mexico, *Univ. Kansas Paleont. Contrib.*, Protozoa, Art.7, pp.1-141, pls.1-24.
- Stelck, C.R., 1950, Cenomanian-Albian Foraminifera of Western Canada, Unpublished Ph.D. Thesis, Stanford Univ., pp.1-207, pls.1-10.
- _____ 1958, Stratigraphic Position of the Viking Sand; *Jour. Alberta Soc. of Pet. Geol.*, Vol.6, No.7, pp.2-7.
- _____ 1962, Upper Cretaceous, Peace River area, British Columbia, *Edmonton Geol. Soc. Fourth Ann. Field Trip, Guidebook*, pp.10-21.
- Stelck, C.R. and Wall, J.H., 1954, Kaskapau Foraminifera from Peace River area of Western Canada; *Research Council of Alberta Rept.* 68, pp.1-38, pls.1-2.
- _____ 1955, Foraminifera of the Cenomanian Dunvegan-oceras Zone from Peace River area of Western Canada, *Res. Coun. Alberta, Report No.70*, pp.1-81, pls.1-9.
- Stelck, C.R., Wall, J.H., Bahan, W.G. and Martin, L.F., 1956, Middle Albian Foraminifera from Athabasca and Peace River Drainage areas of Western Canada; *Research Council Alberta Rept.* 75, pp.1-60, pls.1-5.
- Stelck, C.R., Wall, J.H., and Wetter, R.E., 1958, Lower Cenomanian Foraminifera from Peace River area, Western Canada, *Res. Coun. Alberta, Geol. Div. Bull.* 2, Pt.1, pp.5-35, pls.1-4.
- Stott, D.F., 1960, Cretaceous rocks between Smoky and Pine Rivers, Rocky Mountain Foothills, Alberta and British Columbia, *G.S.C. Paper* 60-16, pp.1-52.
- _____ 1961a, Dawson Creek map-area, British Columbia, *Geol. Surv. Can. Paper* 61-10, pp.1-32.
- _____ 1961b, Type sections of some formations of the Lower Cretaceous Fort St. John Group near Pine River British Columbia, *Geol. Surv. Can. Paper* 61-11, pp.1-61.
- _____ 1962, Cretaceous Rocks of Peace River Foothills, *Edmonton Geol. Soc. Fourth Ann. Field Trip Guidebook*, pp.22-45.

- Stott, D.F., 1963, Stratigraphy of the Lower Cretaceous Fort St. John Group and Gething and Cadomin Formations, Foothills of Northern Alberta and British Columbia, G.S.C. Paper 62-39, pp.1-48.
-
- _____ 1968a, Cretaceous Stratigraphy between Tetsa and LaBiche Rivers, Northeastern British Columbia, Geol. Surv. Can. Paper 68-14, pp.1-41.
-
- _____ 1968b, Lower Cretaceous Bullhead and Fort St. John Groups, between Smoky and Peace Rivers, Rocky Mountain Foothills, Alberta, G.S.C. Bull.152, pp.1-279.
- Takayanagi, Y., 1960, Cretaceous Foraminifera from Hokkaido, Japan, Science Reports of Tohoku University, Sendai, Japan, Second Series (Geology), Vol.32, No.1, pp.1-154, pls.1-11.
- Tappan, H., 1940, Foraminifera from the Grayson Formation of Northern Texas, Jour. Paleo., Vol.14, No.2, pp.93-126, pls.14-19.
-
- _____ 1941, New Arenaceous Foraminifera from the Woodbine Sand of Northern Texas, Jour. Paleo., Vol.15, No.4, pp.359-361, pl.51.
-
- _____ 1943, Foraminifera from the Duck Creek Formation of Oklahoma and Texas, Jour. Paleo., Vol.17, No.5, pp.476-517, pls.77-83.
-
- _____ 1951, Northern Alaska Index Foraminifera, Contrib. Cushman Found. Foram. Res., Vol.2, Pt.1, pp.1-8, pl.1.
-
- _____ 1957, New Cretaceous Index Foraminifera from Northern Alaska, in U.S. Natl. Museum Bull.215, pp.201-222, pls.56-71.
-
- _____ 1960, Cretaceous Biostratigraphy of Northern Alaska, Bull. Amer. Assoc. Pet. Geol. Vol.44, No.3, Pt.1, pp.273-297, pls.1,2.
-
- _____ 1962, Foraminifera from the Arctic Slope of Alaska, Part 3, Cretaceous Foraminifera: U.S. Geol. Survey Prof. Paper 236-C, pp.91-209, pls.29-58.
- Taylor, G.C., and Stott, D.F., 1968, Fort Nelson, British Columbia, Geol. Surv. Can. Paper 68-13, pp.1-23.
- Thorsteinsson, R., 1952, Grande Cache Map-Area Alberta, Geol. Surv. Can. Paper 52-26, pp.1-44.
- Trollope, F.H., 1951, A Lower Microfauna of the Loon River Formation, Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-62, pl.1.

- Wall, J.H., 1951, Cenomanian-Turonian Foraminifera from Kaskapau Formation, Peace River Area, Western Canada, Unpublished M.Sc. Thesis Univ. Alberta, pp.1-134, pls.1-3.
-
- _____ 1960, Upper Cretaceous Foraminifera from the Smoky River Area, Alberta, Res. Coun. Alberta Bull. 6, pp.1-43.
-
- _____ 1967a, Cretaceous Foraminifera of the Rocky Mountain Foothills, Alberta, Res. Coun. Alberta Bull.20, pp.1-185, pls.1-19.
-
- _____ 1967b, Paleoecology of Cretaceous Marine Microfaunas in the Rocky Mountain Foothills of Alberta and British Columbia, in Paleoenvironments of the Cretaceous Seaway in the Western Interior, A Symposium, Colorado School of Mines, pp.173-196.
-
- _____ 1967c, Microfauna of the Cretaceous Alberta Shale on Deer Creek, International Boundary, Great Plains Region, Proc. Geol. Assoc. Can., Vol.18, pp.93-108, pl.1.
- Wall, J.H. and Germundson, R.K., 1963, Microfaunas, Megafaunas and Rock-stratigraphic units in the Alberta Group (Cretaceous) of the Rocky Mountain Foothills, Bull. Can. Pet. Geol., Vol.11, No.4, pp.327-349.
- Warren, P.S. and Stelck, C.R., 1958, Lower Cenomanian Ammonoidea and Pelecypoda from Peace River Area, Western Canada, Res. Coun. Alberta, Geol. Div. Bull.2, Pt.11, pp.36-51, pls.5-16
-
- _____ 1959, Evolutionary Trends Within Gastropod Ammonoids, Trans. Roy. Soc. Can., Sect.4, Series 3, Vol.53, pp.13-20.
-
- _____ 1969, Early Neogastropods, Fort St. John Group, Western Canada, Bull. Can. Pet. Geol., Vol.17, No.4, pp.529-547, pls.1-4.
- Wetter, R.E., 1951, A Cenomanian Microfauna from Upper Fort St. John Strata, Unpublished M.Sc. Thesis, Univ. Alberta, pp.1-48, pls.1-3.
- Whiteaves, J.F., 1885, Description of a New species of Ammonite from the Cretaceous Rocks of Fort St. John on the Peace River, Royal Soc. Can. Proc. and Trans., Sect.4, Vol.2, pp.239-240.

- Wickenden, R.T.D., 1932a, New species of Foraminifera from the Upper Cretaceous of the Prairie Provinces, Proc. Royal Soc. Can., Sect.4, Series 3, Vol.26, pp.85-92, pl.1.
- _____ 1932b, A useful Foraminifera Horizon in the Alberta Shale of Southern Alberta, Jour. Paleo., Vol.6, No.2, pp.203-207, pl.29.
- _____ 1941, Cretaceous Marine Formations Penetrated in Wells near Lloydminster, Sask., Trans. Royal Can. Inst. Vol.23, Pt.2, pp.147-155.
- _____ 1945, Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan, Geol. Surv. Canada, Mem.239, pp.1-87.
- Wickenden, R.T.D. and Shaw, G., 1943, Stratigraphy and Structure in the Mount Hucross-Commotion Creek Map-Area British Columbia, Geol. Surv. Can. Paper 43-13, pp.1-14.
- Williams, G.D. and Burk, C.F., 1964, Upper Cretaceous in Geological History of Western Canada, Alberta Society of Petroleum Geologists, pp.1-232.
- Wulf, G.R., 1962, Lower Cretaceous Albian Rocks in Northern Great Plains, Bull. Amer. Assoc. Pet. Geol., Vol. 46, No.8, pp.1371-1415.

APPENDIX A

SAMPLE DESCRIPTIONS

All samples have been collected from surface outcrops and cover five foot intervals. The sample intervals are based on the top of the Goodrich Sandstone as datum.

Interval	Description	Outcrop Number	Total Section
967'-972'	Sandstone - medium grey, non-calcareous, very fine grained, well sorted with micro cross-bedding, contains fish scales. Some interbedded shale, medium to dark grey non-calcareous (beds to 1")	1	5'
	BASE FISH SCALE SANDSTONE		
	TOP OF LOWER CRUISER SHALE		
963'-967'	Shale - medium to dark grey, fissile, non-calcareous with trace thinly bedded sandstone, light grey, very fine grained. (beds to 1")		9'
135'-963'	Covered Interval		837'
130'-135'	Shale - medium to dark grey, fissile, non-calcareous, contains some fish scales, weathered surface brown.	2	842'
116'-130'	Shale - medium to dark grey, non-calcareous, sandy, contains some fish scales, weathered surface brown. Interbedded sandstone, medium grey, non-calcareous, banded. (sandstone beds to 2")		856'

Interval	Description	Outcrop Number	Total Section
114'-116'	Shale - medium grey, non-calcareous, very sandy, weathered surface brown.	2	858'
73'-114'	Covered Interval		899'
60'-73'	Shale - medium grey, non-calcareous, weathered surface brown.	3	912'
60'-0'	Covered Interval		972'
	TOP OF GOODRICH SANDSTONE Upper Sandstone Unit		
0'-8'	Sandstone - medium grey, fine grained, non-calcareous banded, with fine crossbedding and worm trails. No sample taken.	3	980'
8'-24'	Shale - medium to dark grey, fissile, non-calcareous.		996'
24'-24'2"	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous.		996'2"
24'2"-26'	Shale - medium to dark grey, fissile, non-calcareous		998'
26'-26'2"	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous		998'2"
26'2"-33'	Shale - medium to dark grey, fissile, non-calcareous, with interbedded sandstone medium grey, very fine grained, non-calcareous (beds to 2")		1005'
33'-38'	Shale - medium to dark grey, sandy, non-calcareous.		1010'
	Top Lower Sandstone Unit		

Interval	Description	Outcrop Number	Total Section
38'-82'	Sandstone - medium grey, fine grained, non-calcareous banded, with fine cross-bedding, worm trails present. Thin interbeds of shale, medium grey, non-calcareous.	3	1054'
82'-152'	Covered Interval		1124'
152'-157'	Shale - medium grey, fissile, non-calcareous, weathered surface brown, recessive unit.	4	1129'
157'-157'2"	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous.		1129'2"
157'2"-164'	Shale - medium grey, fissile non-calcareous, weathered surface brown, recessive unit.		1136'
164'-164'2"	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous.		1136'2"
164'2"-182'	Shale - medium grey, fissile, non-calcareous, weathered surface brown, recessive unit.		1154'
182'-182'2"	Ironstone concretions - surface dark brown, weathered surface rusty brown, calcareous.		1154'2"
182'2"-183'10"	Shale - medium grey, fissile, non-calcareous with a trace of inter-bedded sandstone, medium grey, fine grained, banded, micro cross-bedding.		1155'10"
183'10"-184'	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous.		1156'

Interval	Description	Outcrop Number	Total Section
184'-202'	Shale - medium grey, fissile, non-calcareous with trace interbedded sandstone, medium grey, fine grained, banded, micro cross-bedding.	4	1174'
202'-202'4"	Ironstone concretions - fresh surface dark brown, weathered surface rusty brown, calcareous, fossil- iferous.		1174'4"

APPENDIX B

NOTE ON PEACE RIVER NOSING

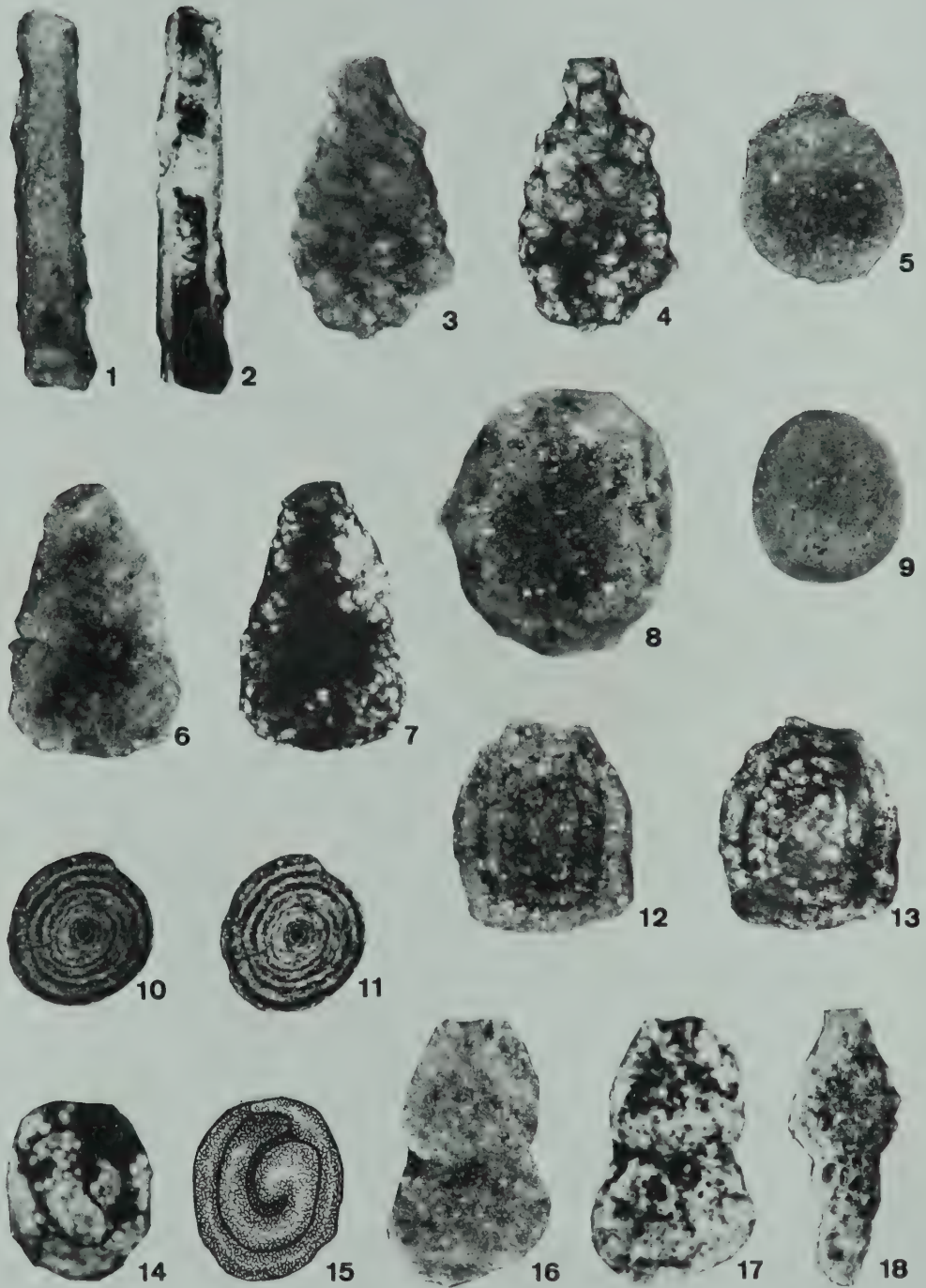
The Peace River nosing is a structural feature which plunges to the east. It extends from Hudson's Hope, British Columbia to just into Alberta with the Peace River flowing approximately along the axis. It was formed before Mowry sea time as both the Goodrich and Sikanni Sands pinch out against the nosing. The Peace River nosing is separate and to the northwest of the Peace River arch.

EXPLANATION OF PLATE 1

All specimens are illustrated at a magnification of approximately 100x unless otherwise stated.

Figure		Page
1,2	<u>Bathysiphon brosgiei</u> Tappan; 1 - side view reflected light; 2 - side view transmitted light, showing wall thickness; G3-58-1; length 0.53 mm.	34
3,4	<u>Saccammina alexanderi</u> (Loeblich and Tappan); 1 - side view reflected light; 2 - side view transmitted light; G3+73-2; length 0.38 mm.	35
5	<u>Saccammina</u> sp. cf. <u>S. lathrami</u> Tappan, side view reflected light; G3-8-3; length 0.33 mm.	38
6,7	<u>Saccammina</u> sp. A; 6 - side view reflected light; 7 - side view transmitted light; G3-28-4; length 0.75 mm; approx. x50	39
8	<u>Saccammina</u> sp. B; side view reflected light; G3-33-5; diameter 0.75 mm; approx. x50.....	40
9	<u>Saccammina</u> sp. C; side view reflected light; G3+73-6; diameter 0.25 mm.	40
10,11	<u>Ammodiscus planus</u> Loeblich, 10 - side view reflected light; 11 - side view transmitted light; G4-192-7; diameter 0.23 mm.	41
12,13	<u>Ammodiscus</u> sp.; 12 - side view reflected light; 13 - side view transmitted light; G3+73-8; diameter 0.30 mm.	42
14,15	<u>Glomospira glomerosa</u> Eicher; 14 - side view reflected light; 15 - drawing opposite side; G3+60-9; diameter 0.25 mm.....	43
16,17	<u>Reophax recta</u> (Beissel); 16 - side view reflected light; 17 - side view transmitted light; G4-157-10; length 0.50 mm.; approx. x75.	44
18	<u>Reophax?</u> sp.; side view reflected light; G3-24-11; length 0.40 mm.	45

PLATE 1



EXPLANATION OF PLATE 2

All specimens are illustrated at a magnification of approximately 100x unless otherwise stated.

Figure		Page
1,2	<u>Miliammina inflata</u> Eicher; 1 - side view reflected light; 2 - opposite side reflected light; G3-24-12; length 0.28 mm.	46
3-5	<u>Miliammina ischnia</u> Tappan; 3 - side view reflected light; 4 - drawing side view; 5 - opposite side reflected light; G3+73-13; length 0.38 mm.	46
6-9	<u>Miliammina</u> sp. cf. <u>M. sproulei</u> Nauss; 6 - side view reflected light; 7 - drawing side view; 8 - opposite side reflected light; 9 - drawing opposite side; G3+64-14; length 0.40 mm.	48
10-13	<u>Miliammina</u> sp.; 10 - side view reflected light; 11 - drawing side view; 12 - opposite side reflected light; 13 - drawing opposite side; G3+73-15; length 0.40 mm.	49
14,17	<u>Psamminopelta bowsheri</u> Tappan; 14 - side view reflected light; 17 - side view transmitted light; G3+73-16; length 0.48 mm.	50
15,16	<u>Psamminopelta bowsheri</u> Tappan; 15 - side view reflected light; 16 - drawing side view; G3-8-18: length 0.41 mm.	50

PLATE 2

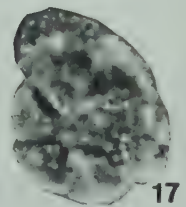
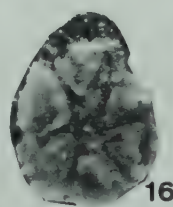
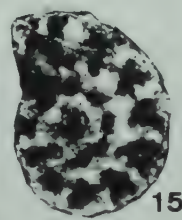
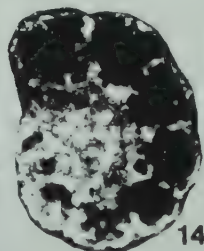
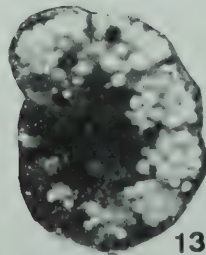
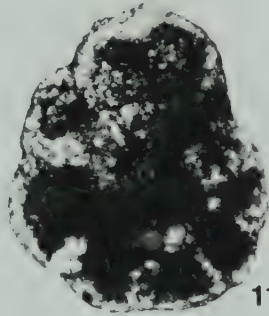
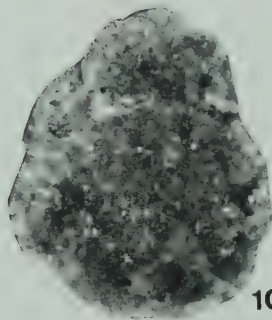
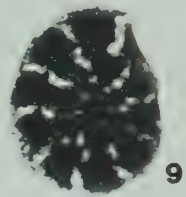
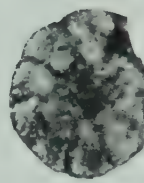
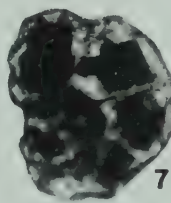
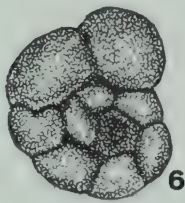
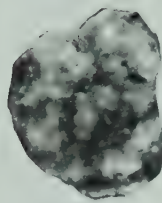
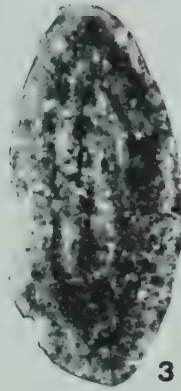
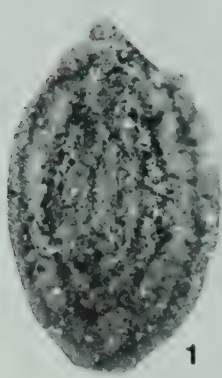


EXPLANATION OF PLATE 3

All specimens are illustrated at a magnification of approximately 100x unless otherwise stated.

Figure		Page
1,2	<u>Psamminopelta bowsheri</u> Tappan; 1 - side view reflected light; 2 - drawing side view; G3-8-36; length 0.48 mm.	50
3,4	<u>Psamminopelta bowsheri</u> Tappan; 2 - side view reflected light; 2 - drawing side view; G2+130-17; length 0.50 mm.	50
5-7	<u>Trochamminoides apricarius</u> Eicher; 5 - side view reflected light; 6 - drawing side view; 7 - opposite side transmitted light; G4-182-19; diameter 0.25 mm.	52
8,9	<u>Haplophragmoides gilberti</u> Eicher; 8 - side view reflected light; 9 - side view transmitted light; G2+114-20; diameter 0.25 mm..	53
10-12	<u>Haplophragmoides</u> sp. cf. <u>H. topagorukensis</u> Tappan; 10 - side view reflected light; 11 - side view transmitted light; 12 - drawing side view; G3-28-25; diameter 0.60 mm., approx. x75.	57
13,14	<u>Haplophragmoides postis</u> subsp. A; 13 - side view reflected light; 14 - side view transmitted light; G3+73-23; diameter 0.33 mm.	56
15	<u>Haplophragmoides postis</u> subsp. A; side view transmitted light; G3+73-24; diameter 0.28 mm.	56
16,17	<u>Haplophragmoides hendersonense</u> Stelck and Wall; 16 - side view reflected light; 17 - opposite side reflected light; G3+73-22; diameter 0.25 mm.	55

PLATE 3

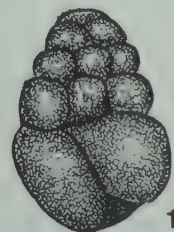
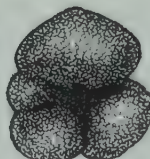
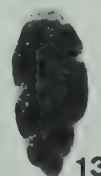
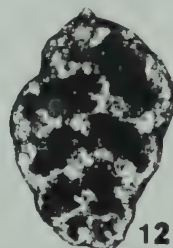
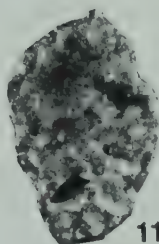
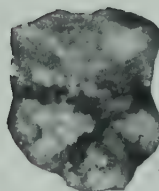
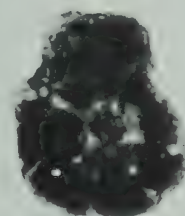
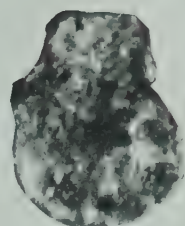
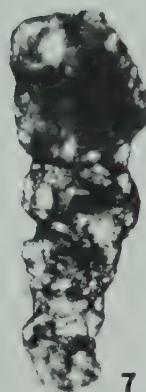
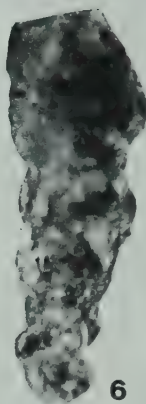
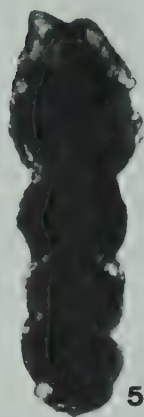
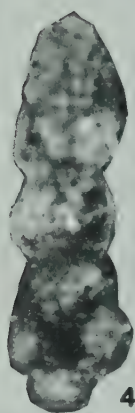
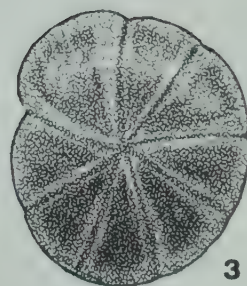
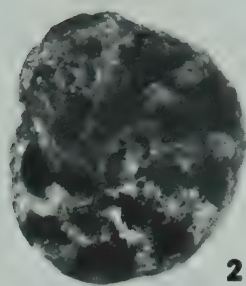
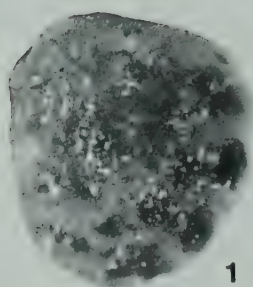


EXPLANATION OF PLATE 4

All specimens are illustrated at a magnification of approximately 100x unless otherwise stated.

Figure		Page
1-3	<u>Haplophragmoides globosa</u> Lozo; 1 - side view reflected light; 2 - side view transmitted light; 3 - drawing side view; G3-34-21; diameter 0.35 mm.	54
4,5	<u>Ammobaculites pacalis</u> subsp. A; 4 - side view reflected light; 5 - edge view transmitted light; G3+60-26; length 0.53	58
6,7	<u>Ammobaculites</u> sp. B; 6 - side view reflected light; 7 - side view transmitted light; G2+114-30; length 0.65 mm., approx. x75....	60
8,9	<u>Ammobaculites</u> sp. A; 8 - side view reflected light; 9 - side view transmitted light; G2+125-29; length 0.28 mm.	60
10	<u>Ammobaculites pacalis</u> subsp. A; side view of coil reflected light; G2+130-28; length 0.23 mm.	58
11,12	<u>Textularia rioensis</u> Carsey; 11 - side view reflected light; 12 - opposite side transmitted light; G3+73-32; length 0.30 mm.....	62
13,14	<u>Textularia</u> sp.; 13 - side view reflected light; 14 - drawing side view; G3-21-33; length 0.23 mm.	64
15,16	<u>Textularia gravenori</u> Stelck and Wall; 15 - drawing side view; 16 - side view transmitted light; G3-28-31; length 0.25 mm.....	61
17-19	<u>Trochammina rutherfordi mellariolum</u> Eicher; 17 - drawing umbilical view; 18 - drawing spiral view; 19 - drawing side view; G2+130-34; diameter 0.20 mm; height of spire 0.30 mm.	64

PLATE 4



EXPLANATION OF PLATE 5

All specimens are illustrated at a magnification of approximately 100x unless otherwise stated.

Figure		Page
1,2	<u>Trochammina umiatensis</u> Tappan; microspheric? form; 1 - spiral view reflected light; 2 - umbilical view reflected light; G2+130-35; diameter 0.38 mm.	66
3,4	<u>Trochammina umiatensis</u> Tappan; megalospheric? form; 3 - spiral view reflected light; 4 - umbilical view reflected light; G4-187-37; diameter 0.33 mm.; approx. 66x	66
5,6	<u>Trochammina wetteri</u> Stelck and Wall; 5 - spiral view reflected light; 6 - umbilical view reflected light; G2+130-38; diameter 0.23 mm.	67
7-10	<u>Trochammina wickendeni</u> Loeblich; 7 - umbilical view reflected light; 8 - drawing umbilical view; 9 - spiral view reflected light; 10 - drawing spiral view; G3-78-39; diameter 0.33 mm.	69
11,12	" <u>Tritaxia</u> " sp. cf. <u>T. manitobensis</u> Wickenden; 11 - side view reflected light; 12 - drawing side view; G2+130-43; length 0.40 mm...	75
13	" <u>Tritaxia</u> " sp. cf. <u>T. manitobensis</u> Wickenden; side view reflected light showing extended aperture on compressed specimen; G3+73-44; length 0.50 mm.	75
14	<u>Gaudryina?</u> sp., side view reflected light of specimen with early chambers broken off; G4-197-45; length 0.45 mm.	76
15,16	<u>Verneuulina alameda</u> Eicher; 15 - drawing of top view; 16 - drawing of side view; G3-24-40; length 0.30 mm.	70
17	<u>Verneuulinoides</u> sp.; drawing side view; G3-28-42; length 0.34 mm.	74
18	<u>Verneuulinoides perplexus</u> (Loeblich); side view reflected light; G2+125-41; length 0.30 mm.	71

EXPLANATION OF PLATE 5 cont'd.

Figure		Page
19,20	<u>Dictyomitra?</u> sp.; 19 - side view reflected light; 20 - drawing side view; G3-21-46; length 0.23 mm.	77
21	Fecal pellet ?; side view reflected light; G3-21-47; length 0.20 mm.	78

PLATE 5



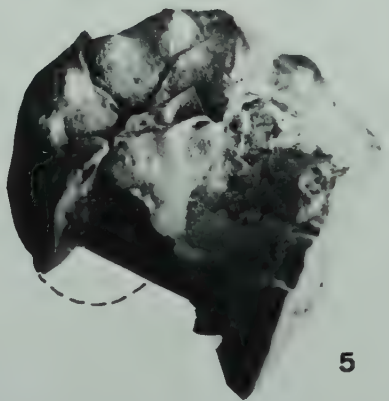
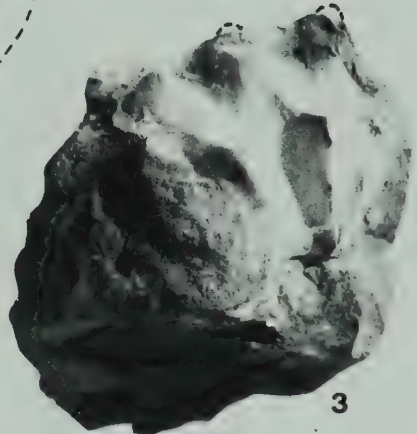
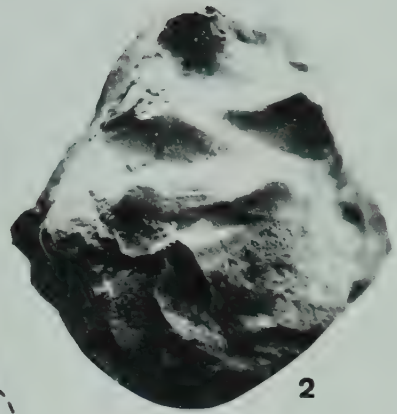
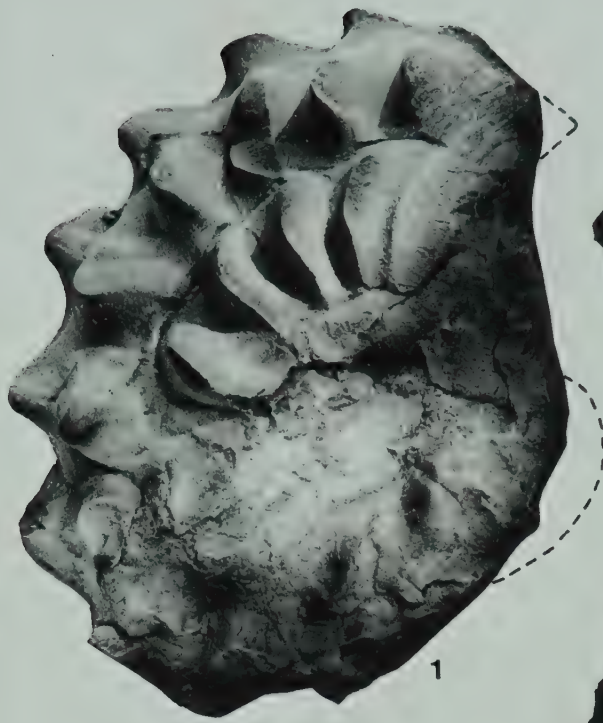
EXPLANATION OF PLATE 6

These zonal ammonites are without systematic description in the text.

Figure

- 1 Neogastrolites cornutus (Whiteaves);
topotype, U.A.40825; lateral view; x.50.
- 2 Neogastrolites haasi Reeside and Cobban;
oblique view, showing size of nodes;
G4-202-48; x.90.
- 3 Neogastrolites haasi Reeside and Cobban;
lateral view; G4-202-48; x.75.
- 4 Neogastrolites haasi Reeside and Cobban;
U.A.39956; lateral view; x.50.
- 5 Neogastrolites sp. cf. N. haasi Reeside
and Cobban; lateral view; G4-202-49; x.75.

PLATE 6



B29979